8. Remedial Investigation/Baseline Assessment Summary and Conclusions

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8. REMEDIAL INVESTIGATION/BASELINE RISK ASSESSMENT SUMMARY AND CONCLUSIONS

The objectives of the WAG 5 comprehensive RI/BRA are to (1) fill data gaps identified in the WAG 5 comprehensive RI/FS Work Plan (DOE-ID 1997), (2) determine the nature and extent of contamination associated with WAG 5 sites, and (3) estimate the current and future comprehensive risk posed by WAG 5 COPCs to human health and the environment. To meet these objectives, the field investigations defined in the WAG 5 Work Plan (DOE-ID 1997) were completed. The new data generated by the field investigations were evaluated in combination with the existing body of information to develop the comprehensive BRA.

The two major operational areas within WAG 5 include ARA and PBF, which comprise nine individual facilities. The ARA includes ARA-I, ARA-II, ARA-III, and ARA-IV. However, only the ARA-IV facility is currently operational and ARA-IV activities are limited to occasional explosives testing. The remaining ARA facilities are in varying stages of D&D. The five operational areas at the PBF originally were known as the Special Power Excursion Reactor Test (SPERT) facilities. The buildings and structures within PBF have been modified to support contemporary programs. The current facilities at PBF are the PBF Control Area, the PBF Reactor Area, the Waste Engineering Development Facility (WEDF), the Waste Experimental Reduction Facility (WERF), and the Mixed Waste Storage Facility (MWSF). The PBF Reactor Area, WEDF, WERF, and MWSF were known historically as SPERT -I, -II, -III, and –IV, respectively.

Thirteen operable units, comprising 55 individual sites, have been identified for WAG 5. Descriptions of the 55 sites, quality assurance and control measures, a facilities assessment analysis, and a summary of site and contaminant screening are contained in Section 3. All historical and potential release sites within WAG 5 were considered as part of the BRA. Previous investigations of the release sites within WAG 5 and the data acquired under the WAG 5 comprehensive FSP (DOE-ID 1997) were reviewed to focus the BRA on those sites with a potential impact on cumulative risk. Fifteen sites were retained for quantitative analysis in the WAG 5 BRA, 12 of which were found to contain sources of contamination that have the potential for producing unacceptable future residential exposure risk (i.e., carcinogenic risk greater than or equal to 1E-06 or a hazard index [HI] greater than or equal to 1.0). Four sites were found to have the potential for producing unacceptable ecological risk (i.e., a hazard quotient [HQ] greater than or equal to 10). The development and results of the quantified evaluation are summarized in the following sections.

8.1 Summary of Individual Site Evaluations

The nature and extent of contamination, fate and transport, and potential human health risks associated with the 15 WAG 5 sites retained for quantitative evaluation in the BRA are discussed in Sections 4, 5, and 6. The analyses in these three sections were developed primarily to support the human health component of the BRA. The source term concentrations also were applied to the ecological risk assessment presented in Section 7. However, the ecological risk assessment component of the BRA includes a separate site and contaminant screening analysis. For the human health risk analysis, the retained sites were evaluated individually for external exposure, soil ingestion, dermal absorption from soil, and ingestion of homegrown produce.

The individual site risks and hazard quotients by exposure pathway for the current occupational, future occupational, and future residential scenarios are summarized in Tables 8-1, 8-2, and 8-3, respectively. The following 12 sites of those quantitatively evaluated contain sources of contamination that have the potential for producing human health risk greater than or equal to 1E-06:

Table 8-1. Summary of individual site risks and hazard quotients for the current occupational scenario.

	Risks				Hazard Quotients		
Site	Total Risk	Ingestion of Soil	External Radiation	Dermal Absorption from Soil	Total Hazard Index	Ingestion of Soil	Dermal Absorption from Soil
ARA-01	2E-04	6E-06	1E-04	7E-05	5E-01	4E-02	5E-01
ARA-02 Soils	4E-05	0E+00	4E-05	0E+00	0E+00	0E+00	0E+00
ARA-02 Seepage Pit	1E-05	0E+00	1E-05	0E+00	0E+00	0E+00	0E+00
ARA-03	5E-05	0E+00	5E-05	0E+00	0E+00	0E+00	0E+00
ARA-12	1E-03	2E-07	1E-03	0E+00	2E-03	2E-03	0E+00
ARA-16	4E-04	2E-06	4E-04	0E+00	0E+00	0E+00	0E+00
ARA-23	2E-04	9E-07	2E-04	0E+00	0E+00	0E+00	0E+00
ARA-24	3E-07	8E-10	1E-12	0E+00	5E-04	0E+00	0E+00
ARA-25	5E-03	2E-05	5E-03	1E-04	9E-01	7E-02	8E-01
PBF-10	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-12	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-16	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-21	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-22	3E-05	2E-06	1E-05	2E-05	2E-01	1E-02	1E-01
PBF-26	1E-04	1E-06	8E-05	2E-05	8E+00	3E-01	8E+00

Table 8-2. Summary of individual site risks and hazard quotients for the future occupational scenario.

Site	Risks				Hazard Quotients		
	Total Risk	Ingestion of Soil	External Radiation	Dermal Absorption from Soil	Total Hazard Index	Ingestion of Soil	Dermal Absorption from Soil
ARA-01	2E-04	6E-06	1E-04	7E-05	5E-01	4E-02	5E-01
ARA-02 Soils	4E-05	0E+00	4E-05	0E+00	0E+00	0E+00	0E+00
ARA-02 Seepage Pit	1E-05	0E+00	1E-05	0E+00	0E+00	0E+00	0E+00
ARA-03	5E-06	0E+00	5E-06	0E+00	0E+00	0E+00	0E+00
ARA-12	6E-04	1E-07	6E-04	0E+00	2E-03	2E-03	0E+00
ARA-16	1E-04	6E-07	1E-04	0E+00	0E+00	0E+00	0E+00
ARA-23	7E-05	4E-07	6E-05	0E+00	0E+00	0E+00	0E+00
ARA-24	3E-07	4E-10	5E-13	0E+00	5E-04	0E+00	0E+00
ARA-25	2E-03	1E-05	1E-03	1E-04	9E-01	7E-02	8E-01
PBF-10	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-12	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-16	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-21	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-22	3E-05	2E-06	1E-06	2E-05	2E-01	1E-02	1E-01
PBF-26	4E-05	1E-06	1E-05	2E-05	8E+00	3E-01	8E+00

Table 8-3. Summary of individual site risks and hazard quotients for the future residential scenario.

	Risks					Hazard Quotients			
Site	Total Risk	Ingestion of Soil	Ingestion of Homegrown Produce	External Radiation	Dermal Absorption from Soil	Total Hazard Index	Ingestion of Soil	Ingestion of Homegrown Produce	Dermal Absorption from Soil
ARA-01[a]	8E-04	5E-05	6E-06	6E-04	2E-04	1E+00	3E-01	6E-06	1E+00
ARA-02 Soils[a]	4E-04	9E-06	1E-06	3E-04	3E-05	2E-01	4E-02	9E-07	2E-01
ARA-02 Seepage Pit	2E-03	3E-05	2E-05	2E-03	7E-05	3E+00	1E+00	3E-05	2E+00
ARA-03	2E-05	2E-08	1E-08	2E-05	0E+00	7E-02	0E+00	7E-09	0E+00
ARA-12	2E-03	4E-07	2E-08	2E-03	0E+00	6E-01	1E-01	0E+00	0E+00
ARA-16	4E-04	8E-07	2E-07	4E-04	0E+00	4E-02	0E+00	7E-09	0E+00
ARA-23[a]	1E-04	3E-07	9E-08	1E-04	0E+00	4E-02	0E+00	7E-09	0E+00
ARA-24	2E-06	2E-09	1E-11	2E-12	0E+00	5E-01	0E+00	0E+00	0E+00
ARA-25	8E-03	1E-04	1E-05	7E-03	3E-04	3E+00	5E-01	1E-05	2E+00
PBF-10	2E-05	2E-08	4E-09	2E-05	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-12	2E-05	4E-07	4E-08	2E-05	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-16	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-21	1E-05	9E-08	1E-08	1E-05	0E+00	0E+00	0E+00	0E+00	0E+00
PBF-22	2E-04	2E-05	3E-06	5E-06	7E-05	8E-01	1E-01	2E-06	4E-01
PBF-26	3E-04	3E-05	7E-06	6E-05	1E-04	2E+01	2E+00	7E-05	2E+01

a. The individual site risk calculations incorporated the uncorrected Ra-226 data in Appendix A. The corrected data in Appendix J (see Giles [1998] in Appendix J) were used to eliminate Ra-226 from evaluation in the WAG 5 feasibility study.

- ARA-01, ARA-I Chemical Evaporation Pond
- ARA-02, ARA-I Sanitary Waste Leach Field and Seepage Pit, which comprises two sources
  - ARA-02 septic tank soils
  - ARA-02 seepage pit
- ARA-03, ARA-I Lead Sheeting Pad near ARA-627
- ARA-12, ARA-III Radioactive Waste Leach Pond
- ARA-16, ARA-I radionuclide tank
- ARA-23, radiologically contaminated surface soils and subsurface structures associated with ARA-I and ARA-II
- ARA-25, ARA-I soils beneath the ARA-626 hot cells
- PBF-10, PBF Reactor Area Evaporation Pond
- PBF-12, SPERT-I Leach Pond
- PBF-21, SPERT-III Large Leach Pond
- PBF-22, SPERT-IV Leach Pond
- PBF-26, SPERT-IV Lake.

The evaluations of these sites are summarized below.

8.1.1 ARA-01 Chemical Evaporation Pond

The ARA-01 site is a shallow, unlined surface impoundment that was used to dispose of wastewater from the ARA-I Shop and Maintenance Building (ARA-627). The pond, located southeast of the ARA-627 building, was excavated in 1971 and received process discharges until 1988. Wastewater discharges contained small quantities of radioactive substances, acids, bases, and VOCs.

In the 1992 remedial investigation of ARA-01 (Stanisich et al. 1992), potential risks from the pond were evaluated. Carcinogenic risks between 1E-07 and 6E-06 for exposures to arsenic, chromium (VI), beryllium, Ba-137m, Co-60, Pu-239, and U-234 were estimated for the 100-year future residential scenario. The total noncarcinogenic hazard index was less than 0.1. A conclusion of the ARA-01 Record of Decision (ROD) (DOE-ID December 1992) is that no remedial action would be necessary for the site; however, the ROD stipulated that additional evaluation of subsurface conditions and the groundwater pathway would be conducted in another operable unit within WAG 5.

Sampling was conducted in 1997 to determine the vertical extent of contamination and the presence and concentrations of alpha-emitting isotopes and Sr-90. Based on the contaminant screening presented in Appendix B, ARA-01 was retained for quantitative risk assessment in the comprehensive BRA to evaluate the risk from contamination detected during the 1992 and 1997 sampling in the evaporation pond soils. The BRA evaluated arsenic, thallium, Am-241, Cs-137, Pu-238, Pu-239/240, Ra-226, Sr-90, and U-235. Lead also was identified as a contaminant of potential concern, but could not be evaluated because toxicity data for lead have not been developed.

The total estimated risk for all pathways for the 100-year future residential scenario is 8E-04. The primary components of the total risk are 6E-04 from Ra-226, 2E-04 from arsenic, and 7E-06 from Cs-137. The noncarcinogenic hazard index for the future residential scenario of 1.0 is from arsenic.

The total risk for all pathways for the current occupational scenario is 2E-04. Carcinogenic excess risks that contributed to the total are 1E-05 from Cs-137, 8E-05 from arsenic, and 1E-04 from Ra-226. The noncarcinogenic hazard index for the current occupational scenario is less than 1.0.

The total estimated risk for all pathways for the 100-year occupational scenario is 2E-04. The primary contributions are 8E-05 from arsenic, 1E-04 from Ra-226, and 1E-06 from Cs-137. The noncarcinogenic hazard index for the future occupational scenario is less than 1.0.

The arsenic and Ra-226 data used in the BRA are presented in Appendix A. The detected concentrations of arsenic at ARA-01 ranged from 11.1 to 25.8 mg/kg, and local background concentrations at the ARA facility ranged from nondetection to 38.7 mg/kg (Stanisich et al. 1992). The average INEEL background concentration for arsenic is 5.8 mg/kg (Rood, Harris, and White 1996). The detected concentrations of Ra-226 at ARA-01 ranged from 1.43 to 3.08 pCi/g. However, the Ra-226 at ARA-01 was analyzed using gamma-ray spectroscopy, which does not have adequate resolution to distinguish between the gamma signatures of Ra-226 and U-235. As a result, the concentrations reported for either radionuclide are biased high (see Giles [1998] in Appendix J). Because the bias is quantifiable, a correction factor was developed that yields correct Ra-226 concentrations. The corrected Ra-226 detections are 0.82 and 1.76 pCi/g, which are less than the INEEL background concentrations for the INEEL of 0.67 to 4.54 pCi/g (Burns 1997). The risk estimates in the BRA are based on the uncorrected data.

8.1.2 ARA-02 Sanitary Waste Leach Field and Seepage Pit

The ARA-02 site consists of a series of three septic tanks, a seepage pit, and the associated piping. Though no known spills or incidents have occurred that would have contaminated the septic system, mixed waste was detected in the septic tanks and seepage pit. As part of a 1996 time critical removal action (Parsons 1996), the three septic tanks were emptied and the seepage pit sludge was sampled (Dietz 1998). The seepage pit and its contents remain in place, along with the empty septic tank structures and piping.

Sampling was conducted in 1997 to determine the vertical extent of chemical and radiological contamination to satisfy the data gap identified in the WAG 5 Work Plan (DOE-ID 1997). The results from the 1997 sampling were combined with data from previous sampling activities to evaluate potential risks.

Because the septic tanks and seepage pit are separated by approximately 400 ft of pipe, the risk for the soil surrounding the three septic tanks was evaluated separately from the seepage pit. The evaluation incorporates the assumption that the pipeline between the septic tanks and the seepage pit is not a source of environmental contamination.

8.1.2.1 ARA-02 Seepage Pit. The contaminants that were evaluated for risk for the ARA-02 seepage pit were arsenic, cadmium, chromium, copper, nickel, silver, Aroclor-1242, diethylether, Ag-108m, Am-241, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Np-237, Pu-238, Pu-239/240, Ra-226, Sr-90, Tc-99, Th-230, U-234, U-235, and U-238. Lead also was identified as a contaminant of potential concern, but could not be evaluated because toxicity data for lead have not been developed. The sludge that remains in the seepage pit was evaluated in the source term for this site. However, historical operational releases were not assessed.

The concentration of Ra-226 in the ARA-02 seepage pit sludge ranged from 1.6 to 89.6 pCi/g. Because the sample concentrations are well above the INEEL background concentration range of 0.67 to 4.54 pCi/g (Burns 1997), a correction factor was not developed (see Giles [1998] in Appendix J).

The total estimated risk associated with the seepage pit for all pathways for the 100-year future residential scenario is 2E-03. The primary components are 2E-03 from Ra-226, 9E-05 from U-235, 7E-05 from Cs-137, 3E-05 from U-238, and 1E-05 from Aroclor-1242. The noncarcinogenic hazard index for the future residential exposure total is 3.0, primarily from Aroclor-1242.

The total estimated risk for all pathways for the current occupational scenario is 1E-05. The primary components are 1E-05 from Ra-226 and 1E-06 from Cs-137. The noncarcinogenic hazard index for the current occupational scenario is less than 1.0.

The total risk estimated for all pathways for the 100-year occupational scenario is 1E-05, attributed primarily to Ra-226. The noncarcinogenic hazard index for the future occupational scenario is less than 1.0.

8.1.2.2 ARA-02 Septic Tank Soil. The contaminants evaluated for risk from the ARA-02 septic tank soils assessment are arsenic, Ra-226, Sr-90, U-234, and U-235. The concentrations of arsenic in the soils at the ARA-02 septic tanks ranged from 2.8 to 7.5 mg/kg, which is less than the local background concentration range of nondetection to 38.7 mg/kg at the ARA facility (Stanisich et al. 1992). The concentration of Ra-226 in the ARA-02 septic tank soils ranged from 1.58 to 2.38 pCi/g, and these numbers were used for the risk assessment calculations (see Appendix A). The corrected concentration range for Ra-226 is from 0.90 to 1.36 pCi/g (see Giles[1998] in Appendix J), which is less than the INEEL Ra-226 background range of 0.67 to 4.54 pCi/g (Burns 1997). The risk estimates below are based on the uncorrected Ra-226 data.

The total estimated risk for all pathways for the 100-year future residential scenario is 4E-04. The primary components are 3E-04 from Ra-226 (using uncorrected data) and 5E-05 from arsenic. The noncarcinogenic hazard index for the future residential exposure total is less than 1.0.

The total risk estimated for all pathways for the current occupational scenario is 4E-05. The primary contributions to this risk are 4E-05 from Ra-226 and 4E-08 from U-235. The noncarcinogenic hazard index for the current occupational scenario is less than 1.0.

The total risk estimated for all pathways for the 100-year occupational scenario is 4E-05, primarily attributed to Ra-226. The noncarcinogenic hazard index for the future occupational scenario is less than 1.0.

8.1.3 ARA-03, ARA-I Lead Sheeting Pad near ARA-627

The ARA-03 site is a contaminated soil area located east of building ARA-627 at ARA-I. The area was identified as contaminated in 1979 during a routine radiation survey. The source of the contamination is uncertain but may have originated either from a tank truck parked at the facility or from cleanup operations following the SL-1 Reactor accident in 1961. Lead sheeting was placed over the site for shielding. The sheeting was removed in 1991, and the site was assessed in a Track 2 investigation (Pickett et al. 1993). Risks were identified from direct exposure to Cs-137 at unacceptable levels. Soil was removed to a depth of 1.1 m (3.5 ft), and Cs-137 was the only contaminant detected above background concentrations in post-removal sampling. The site was backfilled and graded with clean soil to a depth of 0.9 m (3 ft) and seeded with grass. The ARA-03 site was evaluated in the quantitative risk assessment for risk from Cs-137.

The total estimated risk for all pathways for the 100-year future residential scenario is 2E-05 and is attributed to Cs-137. The noncarcinogenic hazard index is not applicable because only carcinogenic risks are evaluated for Cs-137.

The total estimated risk for all pathways for the current occupational scenario is 5E-05 from Cs-137. The noncarcinogenic hazard index for the current occupational scenario is not applicable.

The total risk estimated for all pathways for the 100-year occupational scenario is 5E-06 from Cs-137. The noncarcinogenic hazard index for the future occupational scenario is not applicable.

8.1.4 ARA-12, ARA-III Radioactive Waste Leach Pond

The ARA-12 site is an unlined surface impoundment constructed in a natural depression west of ARA-III across Wilson Boulevard. The pond was constructed to receive low-level liquid waste from reactor research operations. Effluent contained chromium and low-level radioactive material. The tanks and waste lines to the leach pond were removed in 1993 during the D&D of ARA-III.

In the 1994 Track 2 evaluation of ARA-12 (Pickett et al. 1994), a risk of 2E-03 was estimated for the 100-year future residential scenario for direct exposure to Ag-108m, Cs-137, and U-238 and a risk of 1E-03 was estimated for the current occupational scenario. The primary risk drivers were identified as Ag-108m, Co-60, and Cs-137 in the direct exposure pathway and chromium in the inhalation of fugitive dust pathway (Pickett et al. 1994). The Track 2 action determination (Pickett et al. 1994) specified that remedial alternatives for ARA-12 would be developed in the WAG 5 comprehensive RI/FS.

The environmental monitoring global positioning radiometric scanner (GPRS) was used in 1997 to survey the ARA-12 site as part of the ARA-24 in situ gamma survey. When data from the GPRS were analyzed, Cs-137 readings greater than 45 pCi/g were indicated for an area just west of the ARA-12 site boundary. Because the area is debris-filled and nearly inaccessible to the GPRS, a germanium spectrometer (Ge-spectrometer) was deployed to determine the horizontal extent of the contamination. Though this area was not included in the BRA, the site boundary will be expanded to include this area when ARA-12 is remediated.

Data from previous sampling activities (Pickett et al. 1994) were used to evaluate the potential risks from chromium, lead, manganese, Ag-108m, Am-241, Co-60, Cs-137, Pu-238, U-234, and U-238.

The total estimated risk for all pathways for the 100-year future residential scenario is 2E-03. The primary contributions are 2E-03 from Ag-108m, 4E-06 from Cs-137, 2E-06 from U-238, and 1E-06 from chromium. The noncarcinogenic hazard index for the future residential exposure is less than 1.0. Using the GPRS data calculations produced an average Cs-137 concentration estimate of 47.4 pCi/g for ARA-12. The qualitative estimated risk based on the GPRS data for external exposure to Cs-137 for the 100-year future residential scenario is 2E-04.

The total estimated risk for all pathways for the current occupational scenario is 1E-03. The primary contributions to this total are 1E-03 from Ag-108m, 2E-04 from Co-60, and 2E-05 from Cs-137. The noncarcinogenic hazard index for the current occupational exposure is less than 1.0.

The total estimated risk for all pathways for the 100-year occupational scenario is 6E-04. The primary contributions to this total are 6E-04 from Ag-108m and 1E-06 from Cs-137. The noncarcinogenic hazard index for the future occupational exposure is less than 1.0.

8.1.5 ARA-16, ARA-I Radionuclide Tank

The ARA-16 site is a 1,000-gal stainless steel underground tank resting within a lidless concrete vault and covered by about 1.1 m (3.6 ft) of soil. From 1959 to 1988, the tank received radioactive liquid waste from the ARA-I hot cells and waste from the materials testing and research and metal etching processes. Through sampling results and anecdotal information, the waste was identified as F-listed mixed waste (40 CFR 261, Subpart D) containing transuranic radionuclides. When ARA-I was shut down in 1988, the tank was partially excavated. All lines were cut and capped, and the contents of the tank were pumped out except for 109 L (29 gal) of liquid and sludge.

According to INEEL risk assessment protocol (LMITCO 1995), the risk posed by the contaminants contained in the tank waste was not evaluated because a release from the tank into the environment has not occurred. However, the remaining waste would pose additional risk if the tank contents were not contained.

The ARA-16 site was retained to evaluate the risk potential from chloride, sulfate, Ag-108m, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Ra-226, and Sr-90 in soil and gravel. The concentration of Ra-226 in the soils around the ARA-16 tank ranged from 1.36 to 5.27 pCi/g, and these numbers were used for the risk assessment calculations (see Appendix A). But the Ra-226 in the ARA-16 soils was analyzed using gamma-ray spectroscopy. The corrected concentrations for Ra-226 are from 0.78 to 3.01 pCi/g (see Giles [1998] in Appendix J), which are less than the Ra-226 background range at the INEEL of 0.67 to 4.54 pCi/g (Burns 1997).

The total estimated risk for the 100-year future residential scenario for the soils around the tank is 4E-04, with the major contributors to the risk being 1E-04 from Cs-137 and 3E-04 from Ra-226 (using uncorrected concentrations). The noncarcinogenic hazard quotient for residential exposure is less than 1.0.

The total estimated risk for all pathways for the current occupational scenario is 4E-04. The carcinogenic excess risk that contributes to this total is 3E-04 from Cs-137, 7E-05 from Ra-226, 1E-06 from Sr-90, 1E-06 from Eu-154, 1E-06 from Eu-152, 4E-06 from Co-60, and 1E-06 from Ag-108m. Cesium-137 is the greatest single contributor at 3E-04. The hazard index for the current occupational exposure is less than 1.0.

The total estimated risk for all pathways for the 100-year occupational scenario is 1E-04. The primary contributions to this total are 4E-05 from Cs-137 and 7E-05 from Ra-226. The noncarcinogenic hazard index for the future occupational exposure is less than 1.0.

8.1.6 ARA-23, ARA-II Radiologically Contaminated Surface Soils Around ARA-I and ARA-II

The ARA-23 site is a 169,000-m^2 area that consists of the windblown contamination area surrounding ARA-I and –II and subsurface structures remaining after D&D within the ARA-I and ARA-II facilities. A Track 1 investigation was initiated for the site in 1993 but was not finalized because the site was reassigned to OU 10-06, the INEEL Site-wide evaluation of windblown contamination. Based on dose equivalent rates (Jorgensen 1995), the boundary of ARA-06 was expanded outward from the SL-1 Burial Ground perimeter fence to include approximately 40% of ARA-23 in the ROD for OU 5-05

(DOE-ID 1996). No unacceptable risks were identified for this area. However, during the 1997 GPRS survey (see Josten [1997] in Appendix J), Cs-137 was detected at levels in excess of 23 pCi/g. Therefore, the soils outside of the Burial Ground fence were evaluated for risk estimates based on the GPRS data. A smaller area was evaluated for the BRA.

The contaminants of concern at the site comprise the radionuclides Am-241, Cs-137, Ra-226, Sr-90, Th-230, and U-235. In 1997, a surface gamma radiation survey was performed using two types of in situ detectors: the GPRS and a germanium spectrometer (see Josten [1997] in Appendix J). Approximately 69,000 in situ gamma radiation measurements were collected at ARA-23. The highest value recorded at the site was 117,961 counts per second, which equates to a Cs-137 concentration of 2,659 pCi/g. Data from the GPRS survey and the germanium spectrometer were combined into a common database, and maps were compiled showing position, data point distribution, bulk gamma radiation, and the Cs-137 concentrations (see Josten [1997] in Appendix J). The highest analytical result for Cs-137 was 2,140 pCi/g. The limited analytical samples that were collected under the Wag 5 Work Plan (DOE-ID 1997) were targeted to define the isopleth boundary of Cs-137 contamination at concentrations greater than 10 pCi/g as opposed to providing analytical results that could be used for risk assessment purposes. Unfortunately, the use of these biased data in the risk assessment did not reflect the actual risk for those areas known to exceed 10 pCi/g by as much as three orders of magnitude.

Concentrations of Ra-226 ranging from 1.1 to 3.6 pCi/g were used for the risk assessment calculations (see Appendix A), but the Ra-226 at ARA-23 was analyzed using gamma-ray spectroscopy. The corrected concentration range for Ra-226 is 0.63 to 2.06 pCi/g (see Giles[1998] in Appendix J), which is less than the range of INEEL background concentrations for Ra-226 of 0.67 to 4.54 pCi/g (Burns 1997).

Based only on analytical results from sampling activities and the samples collected at the approximate 10 pCi/g isopleth, the estimated total risk for all pathways for the 100-year future residential scenario is 1E-04. The carcinogenic excess risk that contributes to this total is 1E-04 from Ra-226 and 2E-05 from Cs-137. The noncarcinogenic hazard index is not applicable. The GPRS data calculations produced an average Cs-137 concentration estimate of 88.5 pCi/g for ARA-23. The estimated risk from the external exposure pathway only for the 100-year future residential scenario is 5E-04. This qualitative risk estimate is biased low because the measurements to determine background were included in the calculations of the average concentration. In addition, only one exposure pathway was evaluated.

The estimated total risk based on sampling for all pathways for the current occupational scenario is 2E-04. The carcinogenic excess risk that contributes to this total is 9E-05 from Cs-137 and 6E-05 from Ra-226. The noncarcinogenic hazard index for the current occupational exposure is not applicable.

The estimated total risk for all pathways for the 100-year occupational scenario is 7E-05. The carcinogenic excess risk that contributes to this total is 2E-04 from Ra-226 and 9E-06 from Cs-137. The noncarcinogenic hazard index is not applicable.

8.1.7 ARA-25, ARA-I Soils Beneath the ARA-626 Hot Cells

The ARA-25 site was discovered at ARA-I during D&D activities while the WAG 5 comprehensive RI/FS was being developed. Initial contamination levels up to 50,000 disintegrations per minute were measured of the soils that sloughed off the underside of the concrete slabs cut out of the ARA-626 Hot Cells. However, the contamination levels were difficult to verify because of the radiological interference generated by the tops of the hot cell floor slabs.

Drains from the decontamination room, the service area, the hot metallurgy area, a hot laboratory, two hot cell isolation areas, and two hot cells were connected by stainless steel piping to the ARA-16 radionuclide tank (ARA-729 tank). The hot cell isolation areas were located immediately behind the hot cells and were used for initial decontamination of equipment removed from the cells and also for repair and modification of equipment.

The contaminant screening and risk evaluation for ARA-25 are presented in Appendix L. The ARA-25 site was retained to evaluate the risk potential from arsenic, copper, lead, manganese, Cs-134, Cs-137, Co-60, Eu-152, Eu-154, Ra-226, Sr-90, and U-235 in the soil. Though the Ra-226 in the ARA-25 soil was analyzed using gamma-ray spectroscopy, a correction factor similar to those applied to other sites in WAG 5 (see Giles [1998] in Appendix J) could not be determined for ARA-25 because the analytical results do not indicate Ra-226 concentrations at or near background levels and the U-235 in the samples was reported as not detected.

The total estimated risk for the 100-year future residential scenario for the soils under the hot cells is 8E-03, with the major contributors to the risk being 5E-03 from Ra-226 and 2E-03 from Cs-137, 4E-04 from arsenic and 2E-06 from Eu-152. The noncarcinogenic hazard quotient for residential exposure is 3.0, and arsenic was the only contributor.

The total estimated risk for all pathways for the current occupational scenario is 5E-03. The carcinogenic excess risk that contributes to this total is 4E-03 from Cs-137, 1E-03 from Ra-226, 1E-04 from arsenic, 3E-05 from Co-60, 6E-05 from Eu-152, 3E-06 from Eu-154, and 1E-06 from Sr-90. The hazard index for the current occupational exposure is less than 1.0.

The total estimated risk for all pathways for the 100-year future occupational scenario is 2E-03. The primary contributions to this total are 1E-03 from Ra-226, 4E-04 from Cs-137, and 1E-04 from arsenic. The noncarcinogenic hazard index for the future occupational exposure is less than 1.0.

8.1.8 PBF-10, PBF Reactor Area Evaporation Pond

The PBF-10 site was a Hypalon-lined surface impoundment with an approximate area of 1,820 m^2 (19,600 ft^2). Effluent routed to the pond from 1972 to 1984 included chromium-contaminated water from the PBF Reactor secondary coolant loop and discharges containing resins, sulfuric acid, and sulfur dioxide from the demineralizer system. Sulfur dioxide was added to the system to change chromium (VI) to chromium(III). Subsequent to 1984, discharges to the pond did not contain chromium. Sampling identified chromium and Cs-137 in the pond sediments at concentrations greater than risk-based levels (Ludi, Burns, and Hardy 1990). The ROD for OU 5-13 (DOE-ID September 1992) specified an interim action to remove sediments with high contaminant concentrations.

A PBF-10 Interim Action in 1994 (Parsons 1995) included excavation of sediments from the pond in areas with a chromium concentration in excess of 800 mg/kg or a Cs-137 concentration greater than 30 pCi/g, and post-removal verification sampling from sediments above and below the liner to verify the adequacy of the Interim Action. Post-removal samples yielded Cs-137 concentrations ranging from 11.17 to 17.5 pCi/g in the four locations sampled above the liner and chromium concentrations ranging from 213.0 to 309.0 mg/kg. One of four locations sampled below the liner had a Cs-137 concentration of 0.04 pCi/g. Cesium was not detected in the other three samples. Chromium was detected below the liner in concentrations ranging from 14.4 to 23.0 mg/kg. In 1995, the pond liner was removed, the berm was pushed into the pond, and the area was graded and seeded with native grasses (see Hiaring [1995] in Appendix J). No analytical sampling was conducted for PBF-10 in 1997 under the WAG 5 Work Plan (DOE-ID 1997). Data from previous sampling and remediation activities were used to evaluate the risk potential from Cs-137 contamination remaining in the evaporation pond soils after the completion of the Interim Action.

The total carcinogenic risk estimated for the 100-year future residential scenario is 2E-05 from Cs-137. The noncarcinogenic hazard index is not applicable.

Because the residual contaminants of potential concern are not in the upper 4 ft of soil, the current and future occupational scenarios are not applicable.

8.1.9 PBF-12, SPERT-I Leach Pond

The PBF-12 site is the historical location of a 4.6 × 13.7-m (15 × 45-ft) diked, unlined surface impoundment originally called the SPERT-I Warm Waste Seepage Pit. The site received radiologically contaminated and nonradioactive overflow from the SPERT-I Reactor pit on a sporadic basis from 1955 to 1964. Waste from the reactor sump also was routed to the pond. In 1984, D&D was performed at the site (EG&G March 1993). Remediation included removing the drain line and the top 0.8 m (2.5 ft) of contaminated soil and backfilling the pond with clean soil. The area was mounded slightly with a 2.4-m (8-ft) cover of clean soil and seeded with grass. Subsequent laboratory analysis of the soil samples indicated that soil contaminated with residual radioactivity remained at the site. Cesium-137 concentrations ranged from 0.57 to 31.4 pCi/g in eight post-D&D samples (Suckel 1984). Two concentrations of U-235 (0.27 and 1.6 pCi/g) and two concentrations of Sr-90 (1.4 and 2.25 pCi/g) were detected. Cobalt-60 was detected in six of eight locations in concentrations ranging from 0.28 to 2.0 pCi/g. Plutonium-238, U-234, and U-238 also were detected at concentrations slightly above background values developed later by Rood, Harris, and White (1996). The PBF-12 site was evaluated to assess the risk potential from Cs-137, Co-60, Pu-238, Sr-90, U-234, U-235, and U-238 contamination in the soils.

The total estimated risk for the 100-year future residential scenario for the soils in the pond is 2E-05, with the major contributors to the risk being 2E-05 from Cs-137 and 2E-06 from U-235. The noncarcinogenic hazard quotient for residential exposure is not applicable.

Because the residual contaminants of potential concern are not in the upper 4 ft of soil, the current and future occupational scenarios were not evaluated. The noncarcinogenic HIs for the current and future occupational scenarios are not applicable.

8.1.10 PBF-16 SPERT-II Leach Pond

The PBF-16 site is a fenced, unlined surface impoundment, located south of the SPERT-II Reactor Building. From 1959 to 1964, the leach pond was used for disposal of demineralizer effluent, water softener waste, emergency shower drain water, and discharges from the floor drains from the reactor building. Only mercury and lead have been detected above INEEL background concentrations (Hillman-Mason et al. 1994).

Mercury was detected at 0.71 mg/kg and eliminated from evaluation in Appendix B. Lead was detected at 32 mg/kg but could not be evaluated for human health risk because toxicity data for lead have not been developed. However, the site was evaluated for ecological risk (see Section 7). A summary of the evaluation is provided in Section 8.5.

8.1.11 PBF-21 SPERT-III Large Leach Pond

The PBF-21 site is the historical location of a leach pond that received waste from the sump pump in the SPERT-III Reactor Building from 1958 to 1968. Primary coolant water was drained to the pond. The pond was characterized in 1982 and subsequently backfilled by the D&D program. The Track 1 evaluation of the site (EG&G 1994) identified unacceptable risk via the external exposure pathway in both the occupational and 100-year future residential intrusion scenarios. Additional samples were collected in 1993 to determine the presence or absence of hazardous substances. No concentrations were detected above risk-based soil concentrations, but the lowest elevation in the pond was not sampled. However, evidence indicates that low-level radioactive contaminated soils are located beneath the surface at depths of 7 to 8 ft. Cesium-137 concentrations were detected in a range from 0.2 to 18.0 pCi/g. Cobalt-60 was detected in concentrations from 0.8 to 6.5 pCi/g. The risk potential from chloride, orthophosphate, sulfate, Co-60, Cs-137, U-234, U-235, and U-238 in the soils at PBF-21 was evaluated in the BRA.

The total estimated risk for the 100-year future residential scenario for the soils in the leach pond is 1E-05, with the major contributors to the risk being 2E-06 from U-238 and 1E-05 from Cs-137. The noncarcinogenic hazard quotient for residential exposure is less than 1.0.

Because the residual contaminants of potential concern are greater than 4 ft below land surface, occupational scenarios were not evaluated.

8.1.12 PBF-22 SPERT-IV Leach Pond

The PBF-22 site was an unlined surface impoundment that received effluent from the SPERT-IV Reactor from 1961 to 1970. The effluent consisted of radiologically contaminated wastewater, emergency shower water, and demineralizer discharges. Occasional discharges from a waste holdup tank were routed to the pond from 1979 to 1981. In the early 1980s, the pond received contaminated primary coolant water from the SPERT-IV Reactor. In 1985, a radiological survey of the pond identified contaminated soil. Approximately six 0.6 × 1.2 × 2.4-m (2 × 4 × 8-ft) boxes of soil were removed and transported to the RWMC. Post-removal sampling data (see Appendix B) were used to evaluate the risk potential from arsenic, manganese, Am-241, Cs-137, Pu-238, Pu-239, Th-228, Th-230, Th-232, U-234, and U-238. Lead also was identified as a contaminant of potential concern, but could not be evaluated because toxicity data for lead have not been developed.

The total carcinogenic risk estimated for the 100-year future residential scenario is 2E-04. The primary contributors to this risk are 2E-04 from arsenic, 3E-06 from U-238, and 3E-06 from Cs-137. The noncarcinogenic hazard quotient for residential exposure is less than 1.

The total estimated risk for all pathways for the current occupational scenario is 3E-05. The carcinogenic excess risks that contribute to this total are from Cs-137 at 8E-06, Th-228 at 1E-06, and arsenic at 2E-05. The noncarcinogenic hazard index for the current occupational exposure is less than 1.0.

The total estimated risk for all pathways for the 100-year occupational scenario is 3E-05, with arsenic being the primary contributor. The noncarcinogenic hazard index for the future occupational exposure is less than 1.0.

8.1.13 PBF-26 SPERT-IV Lake

The PBF-26 site is a surface impoundment constructed in 1960 by raising a dike 91 m (300 ft) long and 1.8 m (6 ft) high, composed of soil and rock, to close off an irregularly shaped natural depression. The dike created a containment area with an approximate volume of 6 million gal. From 1961 to 1970, the lake received uncontaminated cooling water, and from 1985 to 1992, the only discharges to the lake were uncontaminated effluent from Three Mile Island studies and discharges generated by periodic testing of emergency eye wash and shower stations. The pipeline to the lake was removed in 1992, ending all discharges. Historical sampling biased to the soil at the discharge pipe outlet yielded a maximum detection of the PCB Aroclor-1254 at 13.0 mg/kg. In addition, potential risks from Cs-137 (at detected concentrations ranging from 2.4 to 7.7 pCi/g), total uranium (at detected concentrations ranging from 3.4 to 5.0 pCi/g), and chromium (at detected concentrations ranging from 7.0 to 64.0 mg/kg) were identified (EG&G 1993).

In 1995, a removal action was planned for this site. Before implementing the removal action, field immunoassay for PCBs was used to determine the vertical and horizontal extent of Aroclor-1254 contamination. However, using the immunoassay kits, only one location was detected with a PCB concentration greater than 10 mg/kg, and the duplicate confirmation sample sent for laboratory analysis indicated PCB levels below 10 mg/kg. It is probable that the 1992 sampling removed the PCB hot spot. Gamma analysis detected Cs-137 in five samples collected with concentrations ranging from 0.70 to 4.7 pCi/g (see Hiaring [1998a] in Appendix J). Data from previous sampling activities (see Appendix B) were used to evaluate the potential risks from arsenic, Aroclor-1254, Cs-137, Pu-238, U-234, U-235, and U-238.

The total carcinogenic risk estimated for the 100-year future residential scenario is 3E-04. The primary contributors to this risk are 2E-04 from arsenic, 7E-05 from Aroclor-1254, 3E-05 from Cs-137, 3E-05 from U-235, and 3E-06 from U-238. The noncarcinogenic hazard quotient for the 100-year future residential exposure is 20 from Aroclor-1254.

The total estimated risk for all pathways for the current occupational scenario is 1E-04. The carcinogenic excess risks that contribute to this total are from Aroclor-1254 at 2E-05, Cs-137 at 7E-05, U-235 at 5E-06, and U-238 at 1E-06. The noncarcinogenic hazard index for the current occupational exposure is 8.0 from Aroclor-1254.

The total risk for all pathways estimated for the 100-year occupational scenario is 4E-05. The noncarcinogenic hazard index for the future occupational exposure is 8.0 from Aroclor-1254.

8.2 Summary of Site Groups Risks

A site grouping was implemented for the definition of the nature and extent of contamination and subsequent cumulative risk assessment for the air and groundwater pathways. Six site groups were identified based on the results of the site screening and the following logic. Sites at ARA-I and ARA-II are in close proximity. Therefore, retained sites within ARA-I and ARA-II were assigned to one site group. An area of about 169,000 m^2 (557,742 ft^2) of windblown contamination surrounds the ARA-I and ARA-II facilities. The second group consists of retained ARA-III sites. At the ARA-III facility, an area of about 37,000 m^2 (121,391 ft^2) of windblown surface soil contamination surrounds an area of contamination from a radioactive leach pond, but the facility is physically removed from the ARA-I and -II areas. Similarly, the five PBF operational areas are several kilometers from the ARA area, and removed from each other by distances ranging from 0.5 to 2.0 km (0.3 to 1.2 mi). Sites at four of the five PBF facilities, the PBF Reactor Area, WERF, WEDF, and the MWSF were retained for quantitative evaluation in the BRA. Therefore, each of the four PBF facilities was identified as a group. The ARA-IV facility and the PBF Control Area were not assigned to site groups because none of the sites within these facilities were retained for quantitative evaluation in the BRA. A radiation field is associated with neither ARA-IV nor the PBF Control Area, and both facilities are distant from the other major WAG 5 operational areas. The six site groups and the number of associated sites that were retained for further evaluation in the WAG 5 BRA are as follows:

Group 1—ARA-I and ARA-II. Six sites were retained for further evaluation.

Group 2—ARA-III. Two sites were retained further evaluation.

Group 3—PBF Reactor Area (SPERT-I). Three sites were retained for further evaluation.

Group 4—PBF WEDF (SPERT-II). One site was retained for further evaluation.

Group 5—PBF WERF (SPERT-III). One site was retained for further evaluation.

Group 6—PBF MWSF (SPERT-IV). Two sites were retained for further evaluation.

The site groups were evaluated for cumulative effects from inhalation of fugitive dust, inhalation of volatiles, groundwater ingestion, dermal absorption of groundwater, ingestion of homegrown produce, and inhalation of water vapors from indoor water use. The site investigations, the nature and extent of contamination, and the risks associated with the grouped sites are provided in Sections 4, 5, and 6. The site group risks and hazard quotients for the current occupational, future occupational, and future residential scenarios by pathway are presented in Tables 8-4, 8-5, and 8-6. Three of the site groups, Groups 1, 2, and 6, contain sources of contamination that have the potential for producing unacceptable risks greater than or equal to 1E-06 for air and groundwater exposure pathways.

8.3 Groundwater Evaluation

The nature and extent of groundwater contamination at WAG 5 was evaluated through the collection and analysis of samples from eight groundwater monitoring wells in and around the ARA and PBF areas. Results from the groundwater sampling were compared to risk-based concentrations (RBCs) and maximum contaminant levels (MCLs) (see Section 4.3). The contaminants that were detected at least once in concentrations exceeding MCLs or RBCs are beryllium, iron, arsenic, and lead. However, as discussed in detail in Section 4.3, concentrations of these contaminants in the aquifer are not attributed to sources at WAG 5.

Beryllium was detected above the RBC of 0.02 μg/L but below the MCL and the Idaho groundwater quality standard of 4 μg/L in three filtered samples collected from monitoring Wells PBF-MON-AQ-001 (from which a duplicate sample was taken) and PBF-MON-AQ-003 during the April 1995 sampling event (see Table 4-1). The PBF-001 sample and sample duplicate and the PBF-003 sample each had a concentration of 1.3 μg/L. However, the April 1995 beryllium results appear questionable because the beryllium concentrations in accompanying unfiltered samples from the same wells were all below the detection level of 0.7 μg/L. Typically, total or unfiltered metal results are expected to equal or exceed concurrently collected filtered samples. Beryllium was not detected in subsequent sampling of PBF-001 and PBF-003 during July 1995. There are no known elevated beryllium concentrations in soils that could be acting as a source for beryllium in groundwater near Well ARA-MON-AQ-004 (see Section 4.2.1 for a discussion of the nature and extent of soil contamination in Group 1, ARA-I and -II). The detection of beryllium in PBF-001 and PBF-003 is

Table 8-4. Summary of site group risks and hazard quotients for the current occupational scenario.

Site Group	Risks: Total Risk	Risks: Inhalation of Fugitive Dust	Risks: Inhalation of Volatiles	Hazard Quotients: Total Hazard Index	Hazard Quotients: Inhalation of Fugitive Dust	Hazard Quotients: Inhalation of Volatiles
1	5E-09	5E-09	0E+00	0E+00	0E+00	0E+00
2	3E-07	3E-07	0E+00	5E-04	5E-04	0E+00
3	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
4	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
5	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
6	2E-08	2E-08	0E+00	8E-04	8E-04	0E+00

Table 8-5. Summary of site group risks and hazard quotients for the future occupational scenario.

Site Group	Risk: Total Risk	Risk: Inhalation of Fugitive Dust	Risk: Inhalation of Volatiles	Hazard Quotients: Total Hazard Index	Hazard Quotients: Inhalation of Fugitive Dust	Hazard Quotients: Inhalation of Volatiles
1	5E-09	5E-09	0E+00	0E+00	0E+00	0E+00
2	3E-07	3E-07	0E+00	5E-04	5E-04	0E+00
3	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
4	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
5	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
6	2E-08	2E-08	0E+00	8E-04	8E-04	0E+00

Table 8-6. Summary of site group risks and hazard quotients for the future residential scenario.

	Risks						Hazard Quotients					
	Air Pathways			Groundwater Use Pathways			Air Pathways			Groundwater Use Pathways		
Site Group	Total Risk	Inhalation of Fugitive Dust	Inhalation of Volatiles	Ingestion	Dermal Absorption	Volatile Inhalation	Total Hazard Index	Inhalation of Fugitive Dust	Inhalation of Volatiles	Ingestion	Dermal Absorption	Volatile Inhalation
1	4E-05	9E-07	0E+00	4E-05	9E-08	0E+00	2E-01	1E-04	0E+00	2E-01	1E-02	0E+00
2	2E-06	2E-06	0E+00	4E-10	5E-19	0E+00	5E-01	1E-02	0E+00	5E-01	1E-02	0E+00
3	4E-12	3E-18	0E+00	4E-12	5E-21	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
4	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
5	4E-11	2E-17	0E+00	4E-11	5E-20	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
6	7E-05	2E-07	0E+00	7E-05	1E-07	0E+00	3E-01	1E-02	0E+00	3E-01	2E-02	0E+00

considered anomalous and not representative of actual groundwater concentrations because (1) unusual quantities were reported, (2) beryllium was not detected in the accompanying unfiltered samples, and (3) in all subsequent results of filtered and unfiltered samples, beryllium was not detected.

The Idaho groundwater quality standard for iron, based on aesthetics, is 300 μg/L (IDAPA 16.01.11.200), and the RBC for iron is 11,000 μg/L (EPA 1997). An MCL has not been established for iron. The Idaho standard was exceeded in total (unfiltered) iron samples collected during July 1995 and August 1997 from Wells ARA-004 and PBF-001. However, all dissolved iron concentrations from these wells were considerably below the Idaho standard. The range of dissolved concentrations in ARA-004 and PBF-001 was from 38 μg/L to less than the detection limit. The RBC was exceeded in the August 1997 unfiltered sample from ARA-004. The 16,000-μg/L iron concentration detected in the August 1997 sample appears anomalous relative to previous sampling events for the well. Unfiltered samples from April and July 1995 contained dissolved iron concentrations of 287 and 616 μg/L, respectively. The elevated iron concentration observed in the August 1997 sample from ARA-004 may have been caused either by laboratory error or by corrosion of the galvanized steel riser pipe used in the well for groundwater sampling. Corrosion of the riser pipe and flaking of the resulting iron oxides could introduce iron oxides into the groundwater sample, which would cause the dissolved iron concentrations in ARA-004 to appear high. No known elevated iron concentrations in soils could act as a source of the high iron concentrations in groundwater near Group 1, ARA-I and -II. The high iron concentration reported for August 1997 sample is considered an anomaly and not representative of true groundwater concentrations based on previous lower iron concentrations reported for Well ARA-004 and the potential for sample contamination from the riser material.

Arsenic has been detected in groundwater samples from WAG 5 at concentrations exceeding the carcinogenic RBC of 0.05 μg/L but below the noncarcinogenic RBC of 11 μg/L and the MCL and Idaho standard of 50 μg/L. Arsenic was detected in the April 1995 filtered sample from Well PBF-MON-AQ-001, but not in the accompanying unfiltered sample (see Table 4-1). Detections occurred again in samples collected during July 1995 in the filtered samples from PBF-MON-AQ-001, from which a duplicate sample was taken, and from Well PBF-MON-AQ-003. However, arsenic was detected only in the unfiltered sample from PBF-MON-AQ-003 during the July 1995 sampling (see Table 4-2). Detection occurred in unfiltered samples from Wells ARA-MON-AQ-001, ARA-MON-AQ-003A, and ARA-MON-AQ-004 from the August 1997 sampling (see Table 4-3). The maximum concentration observed was 3.7 μg/L in the unfiltered sample collected during July 1995 from PBF-MON-AQ-003. Arsenic, however, is a ubiquitous element in the soils and basalt rock at the INEEL. The U.S. Geological Survey (USGS) estimates a background concentration of dissolved arsenic in groundwater at the INEEL of 2 to 3 μg/L (Orr, Cecil, and Knobel 1991). Because all of the detections of arsenic (both dissolved and total) in groundwater samples fall within the established background concentrations of dissolved arsenic, existing arsenic in groundwater at WAG 5 is considered to be naturally occurring.

Neither an RBC nor an MCL has been calculated for lead (dissolved or total) in groundwater because toxicity data for lead have not been developed. However, the EPA has established an action level for lead concentration at the tap, or faucet, of 15 μg/L (EPA 1996). The Idaho groundwater quality standard for lead also is 15 μg/L (IDAPA 16.01.11.200). Three wells in the ARA area (ARA-MON-AQ-001, -003A, and -004) and two wells in the PBF area (PBF-1 and SPERT-1) had at least one ground water sample for which either the total (unfiltered sample) or dissolved (filtered sample) lead concentration exceeded 15 μg/L (see Tables 4-1, 4-2, and 4-3). A total of eight samples from these five wells contained lead concentrations that exceeded 15 μg/L, though only two of those eight samples were dissolved lead samples. In summary, elevated lead concentrations that exceed the action level of 15 μg/L could occur in groundwater at WAG 5. Sporadic high values provide evidence to support this conclusion, though no clear trend can be determined because of the relatively small data set available for analysis. In an evaluation of the combined filtered and unfiltered lead data collected for the WAG 5 comprehensive RI/FS, a determination could not be made of a statistically significant increase in lead concentrations in WAG 5 monitoring wells over those in the combined USGS data set. This does not, however, rule out the possibility of elevated lead concentrations in an individual well. Additional monitoring data will be used as they become available to further evaluate lead in groundwater at WAG 5. Regardless of whether lead concentrations are elevated, it does not appear that lead contamination in soils at WAG 5 could be a source of lead contamination in groundwater beneath WAG 5. Modeling of lead-contaminated soils using GWSCREEN, discussed further in Section 5, indicates that the maximum groundwater concentration from known WAG 5 lead sources is approximately 1 µg/L. This peak concentration is estimated to occur at greater than 19,000 years in the future.

Groundwater fate and transport modeling was used to predict the maximum contaminant concentrations that could occur in the aquifer from leaching and transport of nonradionuclide and radionuclide contaminants from WAG 5 release sites. The GWSCREEN model was used to simulate the potential release of contaminants from the release sites and the transport of the contaminants through the vadose zone to the aquifer. The maximum 30-year average groundwater concentration for each COPC was estimated at 100 and 1,000 years in the future, and at the time of maximum contaminant concentration up to 10,000 years. The mean dissolved lead concentrations from all samples collected from the USGS background wells were statistically compared to the mean dissolved lead concentrations from the all WAG 5 groundwater samples using a standard Student-T test for the two sample populations (Devore and Peck 1990). The 31 samples from the 13 USGS monitoring wells have an arithmetic mean concentration of 3.4 µg/L with a standard deviation of 3.7 µg/L. The 14 dissolved lead samples collected for the RI/FS from six INEEL wells have a mean concentration of 7.4 µg/L with a standard deviation of 4.8 µg/L.

The GWSCREEN results indicated that no retained sites at WAG 5 contain sources of contamination that have the potential for producing unacceptable risk in the groundwater greater than 1E-04 or a hazard quotient greater than 1 for groundwater ingestion, as listed in Appendix B (see Tables B-80 through 93). In addition, no site groups showed potentially unacceptable risks in the air and groundwater residential scenarios greater than 1E-04 or hazard quotients greater than 2.

8.4 Human Health Risk Evaluation Summary

The WAG 5 comprehensive human health risk assessment consists of two broad phases of analysis:

1. Site and contaminant screening identifies release sites and COPCs that could produce adverse human health impacts to current and future workers and future residents at WAG 5. The risk assessment also presents information about the release mechanisms responsible for the contamination, detected contaminants, and the source term estimates for assessing the baseline risk.

2. An exposure route analysis produces estimates of the human health risk for each COPC. The exposure route analysis includes an exposure assessment, a toxicity assessment, and a risk characterization. The BRA includes an evaluation of human health risks associated with exposure to contaminants through soil ingestion, fugitive dust inhalation, volatile inhalation, external radiation exposure, groundwater ingestion, ingestion of homegrown produce, dermal absorption of groundwater, dermal absorption from soil, and inhalation of water vapors from indoor water use. Occupational health risks were estimated for the current scenario and for a future scenario beginning in 100 years. For the future residential scenario, risks were estimated beginning 100 years from now for all exposure pathways. In addition,

future residential groundwater ingestion risk was estimated at peak contaminant concentration or 10,000 years in the future, whichever occurred first.

Radium-226 was identified as a COPC for several of the sites evaluated in the BRA. In most cases, gamma-ray spectroscopy was the analytical method used to identify Ra-226 concentrations. However, this method does not provide sufficient resolution to discriminate Ra-226 from U-235. Therefore, a correction factor was developed (see Giles [1998] in Appendix J). For those sites at which the corrected Ra-226 concentrations were at or below background values, Ra-226 was eliminated as a COPC. The sites that were affected by the correction factor were ARA-01, ARA-02 septic tank soils, ARA-16 soils, and ARA-23.

For arsenic, background concentrations at WAG 5 are typically higher than the INEEL background value of 5.8 mg/kg developed by Rood, Harris, and White (1996). The range of local background concentrations at ARA is between nondetection and 38.7 mg/kg (Stanisich et al. 1992) and 4.5 to 7.9 mg/kg at PBF (Martin et al. 1990). Based on the local background values, arsenic was eliminated as a COPC at ARA-01, ARA-02, and PBF-22.

The results of the human health risk assessment relative to the evaluated exposure routes are summarized in Tables 8-1 through 8-6. The individual release sites for which the estimated risks exceed 1E-04 are indicated in Tables 8-1 through 8-3. The total estimated risk for each site group (i.e., air and groundwater exposure routes) was less than 1E-04 (see Tables 8-4 through 8-6). The exposure routes with estimated carcinogenic excess risks greater than or equal to 1E-04 or a noncarcinogenic hazard index greater than or equal to 2 are ingestion of soil, dermal absorption from soil, and external radiation exposure. The associated contaminants of concern (COC) in soil for the future residential scenario are arsenic, Ag-108m, Cs-137, and Ra-226. In addition, Ra-226, U-235, U-238, and Aroclor-1242 are COCs for the ARA-02 seepage pit sludge.

None of the site groups for air and groundwater pathways had risks greater than 1E-04 or hazard quotients greater or equal to 1. Three of the site groups, Group 3 (PBF Reactor Area), Group 4 (PBF WEDF), and Group 5 (PBF WERF), had a total risk less than 1E-06 and a hazard index less than 1. Three of the site groups had estimated risks greater than 1E-06 and less than 1E-04 as follows:

- Group 1 (ARA-I and ARA-II). In this group, an ingestion of groundwater risk of 4E-05 was estimated for arsenic.

- Group 2 (ARA-III). In this group, the total inhalation of fugitive dust risk of 1E-06 was estimated for chromium.

- Group 6 (PBF MWSF). In this group, an ingestion of groundwater risk of 7E-05 was estimated for arsenic.

8.5 Ecological Risk Evaluation Summary

The WAG 5 ecological risk assessment (ERA) is a component of the three-phased approach developed for ERA at the INEEL. The first phase, the ecological site and contaminant screening, determined which sites and contaminants would be subjected to further analysis in the WAG 5 comprehensive RI/FS. The second phase of the ERA is a site-by-site evaluation of the risks to ecological resources as a result of exposure to contaminants at the WAG level. The second-phase evaluation included a review of the screening completed in Phase 1 to ensure that sites or contaminants were not inappropriately omitted from further evaluation. The final phase is the integration of WAG-wide ERAs into a final INEEL-wide evaluation of potential risks to ecological receptors. Phase 1 of the ERA was completed and documented in the WAG 5 Work Plan (DOE-ID 1997). The second phase, presented in Section 7, was included as a component of the WAG 5 comprehensive RI/BRA. Phase 3 will be completed in the future under the OU 10-04 comprehensive RI/FS as a component of the INEEL-wide ERA.

A complete discussion of the second phase of the WAG 5 ERA is presented in Section 7. Sixteen of the 55 sites within WAG 5 were retained for evaluation on a site-by-site basis. In addition, the contaminant screening is presented and conceptual site models are developed to support the evaluation. Surface and subsurface soils were the only media considered. Groundwater was eliminated as a medium of concern in the ERA because it is not accessible to ecological receptors. Surface water was eliminated because no significant surface water features are contained within WAG 5. The analysis addresses contaminant fate and transport properties, ecological exposure assessment, contaminant toxicity, and uncertainties inherent in the evaluation to develop a foundation for the ecological risk characterization.

All radionuclides were eliminated in the contaminant screening process. Therefore, the risk characterization generated a quantitative assessment of the potential risk for nonradiological contaminants. Hazard quotients were developed for each contaminant, functional group, and threatened or endangered species (T/E) and species of special concern (C2 species) potentially associated with each evaluated site in WAG 5. If the approximated dose of a given contaminant did not exceed its toxicity reference value (i.e., if the contaminant had a hazard quotient of less than 1.0 for nonradiological constituents), adverse effects to ecological receptors are not expected and no further evaluation was recommended.

Potential unacceptable ecological risks were identified for eight sites. A summary of the sites and contaminants generating potential unacceptable risk for the sites evaluated in the WAG 5 comprehensive RI/BRA is given in Table 8-7.

Table 8-7. Summary of potential unacceptable ecological risks at WAG 5.

Site	Description	Contaminant	Hazard Quotient
ARA-01	ARA-I Chemical Evaporation Pond	Antimony	≤ 1 to ≤ 10
		Arsenic	≤ 1 to ≤ 20
		Cadmium	≤ 1 to ≤ 1,000
		Copper	≤ 1 to ≤ 10
		Lead	≤ 1 to ≤ 60
		Selenium	≤ 1 to ≤ 300
		Thallium	≤ 1 to ≤ 300
		Vanadium	≤ 1 to ≤ 200
		Zinc	≤ 1 to ≤ 20
ARA-02	Septic tank soils	Barium	≤ 1
		Chromium(III)	≤ 1
		Copper	≤ 1
ARA-12	Radioactive waste leach pond	Cadmium	≤ 1 to ≤ 2,000
		Chromium(III)	≤ 1 to ≤ 9

Table 8-7. (continued).

Site	Description	Contaminant	Hazard Quotient
		Copper	≤ 1 to ≤ 300
		Lead	≤ 1 to ≤ 300
		Manganese	≤ 1 to ≤ 40
		Mercury	≤ 1 to ≤ 90
		Selenium	≤ 1 to ≤ 30
		Zinc	≤ 1 to ≤ 50
ARA-25	ARA-I Soils Beneath the ARA-626 Hot Cells	Arsenic	≤ 1 to ≤ 20
		Cobalt	<1 to ≤90
		Copper	≤ 1 to ≤ 40
		Lead	≤ 1 to ≤ 900
		Manganese	≤ 1 to ≤ 6
		Mercury	≤ 1 to ≤ 3
		Nickel	≤ 1 to ≤ 6
		Selenium	≤ 1 to ≤ 3
		Silver[g]	≤ 1 to ≤ 3[c]
		Vanadium	≤ 1 to ≤ 100
		Zinc	≤ 1 to ≤ 20
PBF-16	SPERT-II Leach Pond	Lead	≤ 1 to ≤ 60
		Mercury	≤ 1 to ≤ 50
PBF-21	SPERT-III Large Leach Pond	Cobalt	≤ 1 to ≤ 6
		Copper	≤ 1 to ≤ 2
PBF-22	Leach pond	Arsenic	≤ 1 to ≤ 8
		Copper	≤ 1 to ≤ 20
		Lead	≤ 1 to ≤ 40
		Mercury	≤ 1 to ≤ 20
		Nickel	≤ 1 to ≤ 10
		Selenium	≤ 1 to ≤ 20
		Aroclor-1254	≤ 1 to ≤ 9
PBF-26	SPERT-IV Lake	Arsenic	≤ 1 to ≤ 8
		Chromium(III)	≤ 1 to ≤ 2
		Copper	≤ 1 to ≤ 100
		Lead	≤ 1 to ≤ 100
		Mercury	≤ 1 to ≤ 20
		Nickel	≤ 1 to ≤ 20
		Zinc	≤ 1 to ≤ 40

8.6 Conclusions

All but 16 of the 55 sites in WAG 5 were eliminated from quantitative analysis based on site and contaminant screening criteria (see Section 3.4). Human health risk estimates were developed for these 15 sites (see Section 6). The contaminants with the greatest potential for causing adverse human health effects at WAG 5 (i.e., the contaminants for which the cumulative risk is greater than 1E-04 or the hazard index is greater than 2) include Ag-108m, Cs-137, Ra-226, U-235, U-238, arsenic, and Aroclor-1242.

Six individual sites, ARA-02 (seepage pit), ARA-12, ARA-16, ARA-23, ARA-25, and PBF-26, contain sources of contamination that have the potential for producing unacceptable risks greater than 1E-04 or a hazard quotient greater than 2 in either the residential or the occupational scenarios, as shown in Tables 8-1 through 8-3. Remedial alternatives are identified and evaluated in the FS (see Sections 9 through 12) for five individual sites, ARA-02 seepage pit, ARA-12, ARA-16, ARA-23, and ARA-25, that contain sources of contamination with the potential for producing unacceptable human health risk in the 100 year future residential scenario. Though PBF-26 contains contamination with an estimated hazard index in excess of 2, it is not recommended for evaluation of remedial alternatives in the FS. The hazard index for PBF-26 is based on PCBs. A single Aroclor-1254 concentration of 13 mg/kg was detected in 1988 (EG&G 1993). A time critical removal action was recommended for the site. In 1995, in preparation for the removal action, field immunoassay kits for PCBs were used to determine the vertical and horizontal extent of contamination. Using the immunoassay kits, only one location was detected with a potential concentration greater than the 10-mg/kg action level identified for the removal action. However, the duplicate confirmation sample sent for laboratory analysis yielded a PCB concentration of only 4.4 mg/kg (see Hiaring [1998a] in Appendix J). Because the analytical results for PCB were below the 10-mg/kg action limit, the planned removal action was not performed. It is possible that the PCB contamination was removed during sampling. Because of the immobility of PCBs, the likelihood that PCB contamination was extremely limited at PBF-26, and field immunoassay not detecting PCBs in excess of 10 mg/kg, which was confirmed by laboratory analysis, PCB-26 was not recommended for analysis of remedial alternatives in the FS.

Eight sites with hazard quotients in excess of 1 were identified in the ERA. An additional screening was performed in which contaminants were eliminated as a concern if the exposure point concentration did not exceed 10 times the background concentration, or if the hazard quotient was less than 10.[a] Sites with ecological hazard quotients greater than 1 but less than 10 will be addressed in the WAG 10 ecological risk assessment for the entire INEEL. The results of the screening for WAG 5 are presented in Table 8-8. Four sites, ARA-01, ARA-12, ARA-25, and PBF-16, were forwarded for evaluation of remedial alternatives in the comprehensive FS (see Sections 9 through 12) to address risks to ecological receptors.

In total, seven sites were identified for evaluation of remedial alternatives in the FS: ARA-02 seepage pit, ARA-16, and ARA-23 for human health risks; ARA-01 and PBF-16 for ecological risks; and ARA-12 and ARA-25 for both human health and ecological risks. The seven sites are illustrated in Figures 8-1 through 8-7. Human health source terms are shown in gold, ecological risk source terms are shown in green, and sites with source terms associated with both human health and ecological risks are shown in violet. The sites are tabulated in Table 8-9 and summarized below:

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a. Webber, F. L., Waste Area Group 5 project manager, Interdepartmental personal communication with N. L. Hampton, Lockheed Martin Idaho Technologies Company.

Table 8-8. Results of WAG 5 ecological contaminant screening against 10-times background concentrations and concentrations equivalent to a hazard quotient of 10.

Site	Contaminant	Maximum Concentration	95% UCL	10X INEEL Background	Maximum Hazard Quotient	Comment	Retain?
ARA-01	Antimony	1.68E+01		4.80E+01	1.00E+01	Below 10X background	no
	Arsenic	2.58E+01		5.80E+01	2.00E+01	Below 10X background	no
	Cadmium	3.80E+00		2.20E+01	1.00E+03	Below 10X background	no
	Copper	2.55E+01		2.20E+02	1.00E+01	Below 10X background	no
	Lead	4.39E+01		1.70E+02	6.00E+01	Below 10X background	no
	Selenium	**2.77E+01**		**2.20E+00**	**3.00E+02**		**YES**
	Thallium	**5.92E+01**	**3.70E+01**	**4.30E+00**	**3.00E+02**		**YES**
	Vanadium	6.80E+01		4.50E+02	2.00E+02	Below 10X background	no
	Zinc	2.33E+02		1.50E+03	2.00E+01	Below 10X background	no
ARA-12	Cadmium	6.52E+00		2.20E+01	2.48E+03	Below 10X background	no
	Chromium(III)	4.69E+02		3.30E+02	9.31E+00	HQ < 10	no
	Copper	**6.23E+02**		**2.20E+02**	**3.00E+02**		**YES**
	Lead	1.58E+02		1.70E+02	3.38E+02	Below 10X background	no
	Manganese	5.70E+02		4.90E+03	3.90E+01	Below 10X background	no
	Mercury	**1.40E+00**		**5.00E-01**	**9.00E+01**		**YES**
	Selenium	**2.70E+00**		**2.20E+00**	**3.00E+01**		**YES**
	Zinc	3.76E+02		1.50E+03	5.29E+01	Below 10X background	no
ARA-25	Arsenic	2.58E+01		5.8E+01	2.00E+01	Below 10X background	no
	Cobalt	1.04E+02		1.10E+02	9.00E+01	Below 10X background	no
	Copper	**2.27E+02**		**2.20E+02**	**4.00E+01**		**YES**
	Lead	**1.43E+03**		**1.70E+02**	**9.00E+02**		**YES**
	Manganese	1.40E+03		4.90E+03	6.00E+00	Below 10X background	no
	Mercury	9.70E-02		5.00E-01	3.00E+00	Below 10X background	no
	Nickel	3.88E+01		3.50E+02	6.00E+00	HQ < 10	no
	Selenium	6.59E-01		2.20E+00	3.00E+00	HQ < 10	no
	Silver	7.24E+00		NA	2.00E+00	HQ < 10	no
	Vanadium	1.04E+02		4.50E+02	1.00E+02	Below 10X background	no
	Zinc	8.55E+02		1.50E+03	3.00E+01	Below 10X background	no
PBF-10	Chromium(III)	3.09E+02		3.30E+02	1.00E+01	Below 10X background	no
PBF-16	Lead	3.21E+01		1.70E+02	6.00E+01	Below 10X background	no
	Mercury	**7.10E-01**		**5.00E-01**	**5.00E+01**		**YES**
PBF-21	Cobalt	1.26E+01		1.10E+02	6.00E+00	Below 10X background	no
	Copper	2.33E+01		2.20E+02	2.00E+00	Below 10X background	no
PBF-22	Arsenic	1.22E+01		5.80E+01	8.33E+00	Below 10X background	no
	Copper	4.84E+01		2.20E+02	2.06E+01	Below 10X background	no
	Lead	6.84E+01		1.70E+02	4.40E+01	Below 10X background	no
	Mercury	2.70E-01		5.00E-01	1.82E+01	Below 10X background	no
	Nickel	4.10E+01		3.50E+02	1.37E+01	Below 10X background	no
	Selenium	1.70E+00		2.20E+00	1.88E+01	Below 10X background	no
PBF-26	Aroclor-1254	1.30E+01		NA	8.54E+00	Eliminated (no source[a])	no
	Arsenic	7.90E+00		5.80E+01	7.90E+00	Below 10X background	no
	Chromium(III)	6.40E+01		3.30E+02	1.95E+00	Below 10X background	no

Table 8-8. (continued).

Site	Contaminant	Maximum Concentration	95% UCL	10X INEEL Background	Maximum Hazard Quotient	Comment	Retain?
	Copper	2.34E+02	1.10E+02	2.20E+02	9.98E+01	95% UCL below 10X background	no
	Lead	4.30E+01		1.70E+02	9.79E+01	Below 10X background	no
	Mercury	3.40E-01		5.00E-01	2.30E+01	Below 10X background	no
	Nickel	4.50E+01		3.50E+02	1.50E+01	Below 10X background	no
	Zinc	2.59E+02		1.50E+03	3.65E+01	Below 10X background	no

a. Aroclor-1254 was eliminated based on removal action confirmation sample data in which levels of 4.4 ppm were detected (see Hiaring [1998a] in Appendix J).

- Site ARA-01 (ARA-I evaporation pond) was forwarded to the FS to address potential risks to ecological receptors from exposure to selenium and thallium in soil.

- Site ARA-02 (ARA-I sanitary waste system) was forwarded to the FS to address the human health risk posed by the COCs Aroclor-1242, Ra-226, Cs-137, U-235, and U-238 still contained in the seepage pit that could be a potential release to the environment. Alternatives for the sludge in the seepage pit should be evaluated separately from the soils exterior to the pit. The composite data used to develop the source term for the baseline risk assessment should not be used for purposes of examining FS alternatives for the soils outside the seepage pit unless additional soil sample data support the assignment of mixed waste codes. The analytical results for the exterior soils indicate that soil concentrations are below risk-based concentrations, and the evaluation of remedial alternatives specific to these soils, if necessary, will be addressed as a part of the remedial design/remedial action (RD/RA) for ARA-23.

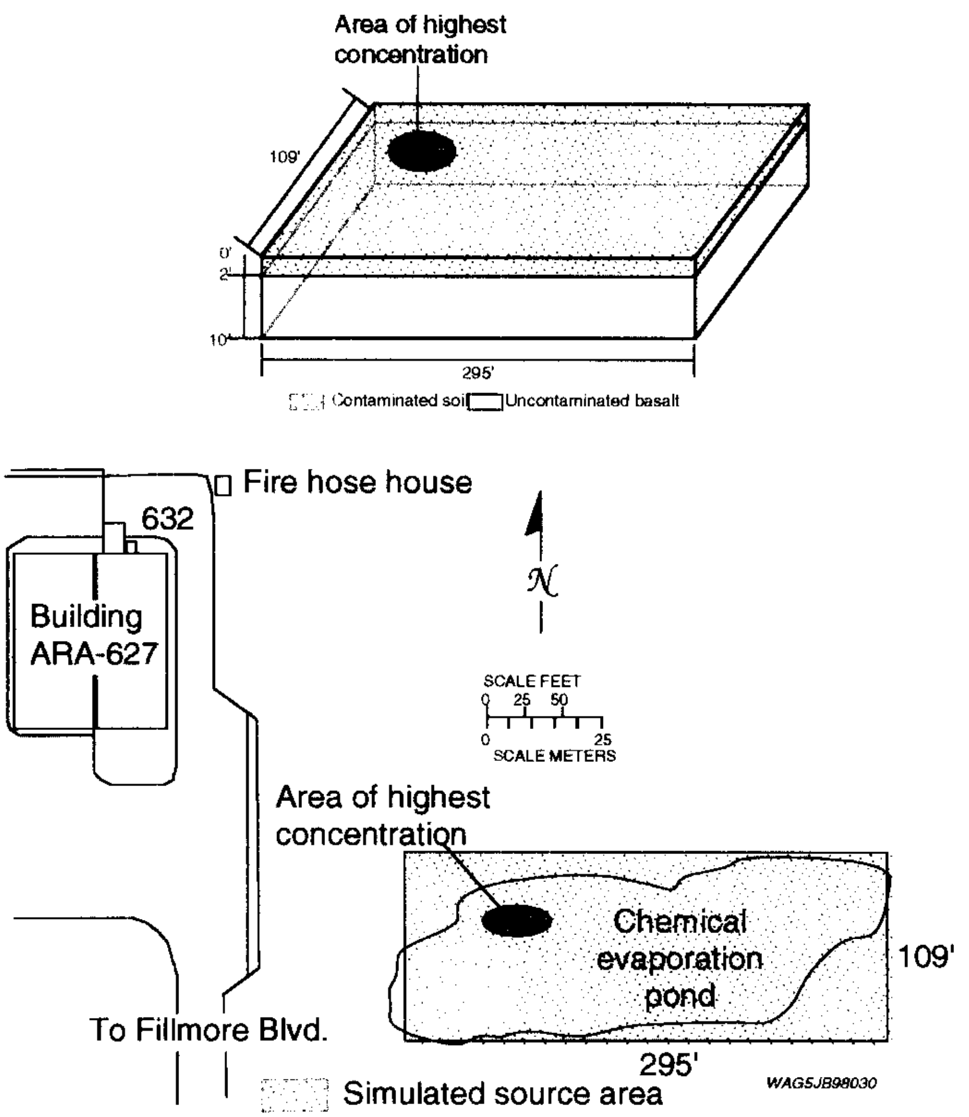
- Site ARA-12 (ARA-III leach pond) was forwarded to the FS to address the human health risks from Ag-108m and Cs-137. The boundaries of the site will be expanded for the RD/RA to encompass the newly identified area of elevated gamma activity to the southwest of the site. The ARA-12 site also was forwarded to the FS to address the ecological risks from copper, mercury, and selenium in surface and subsurface soil.

- Site ARA-16 (ARA-I radionuclide tank) was forwarded to the FS to address the human health risk from Cs-137 in the soils surrounding the tank. Because the ARA-16 tank is still in place and contains waste that could pose a risk should a release to the environment occur, remedial alternatives for the tank and the associated piping also have been forwarded for evaluation in the FS.

- Site ARA-23 (windblown contaminated soils) was forwarded to the FS to address the human health risks from Cs-137. The site includes the radiologically contaminated soils around ARA-I and ARA-II and the remaining substructures within the facility fences.

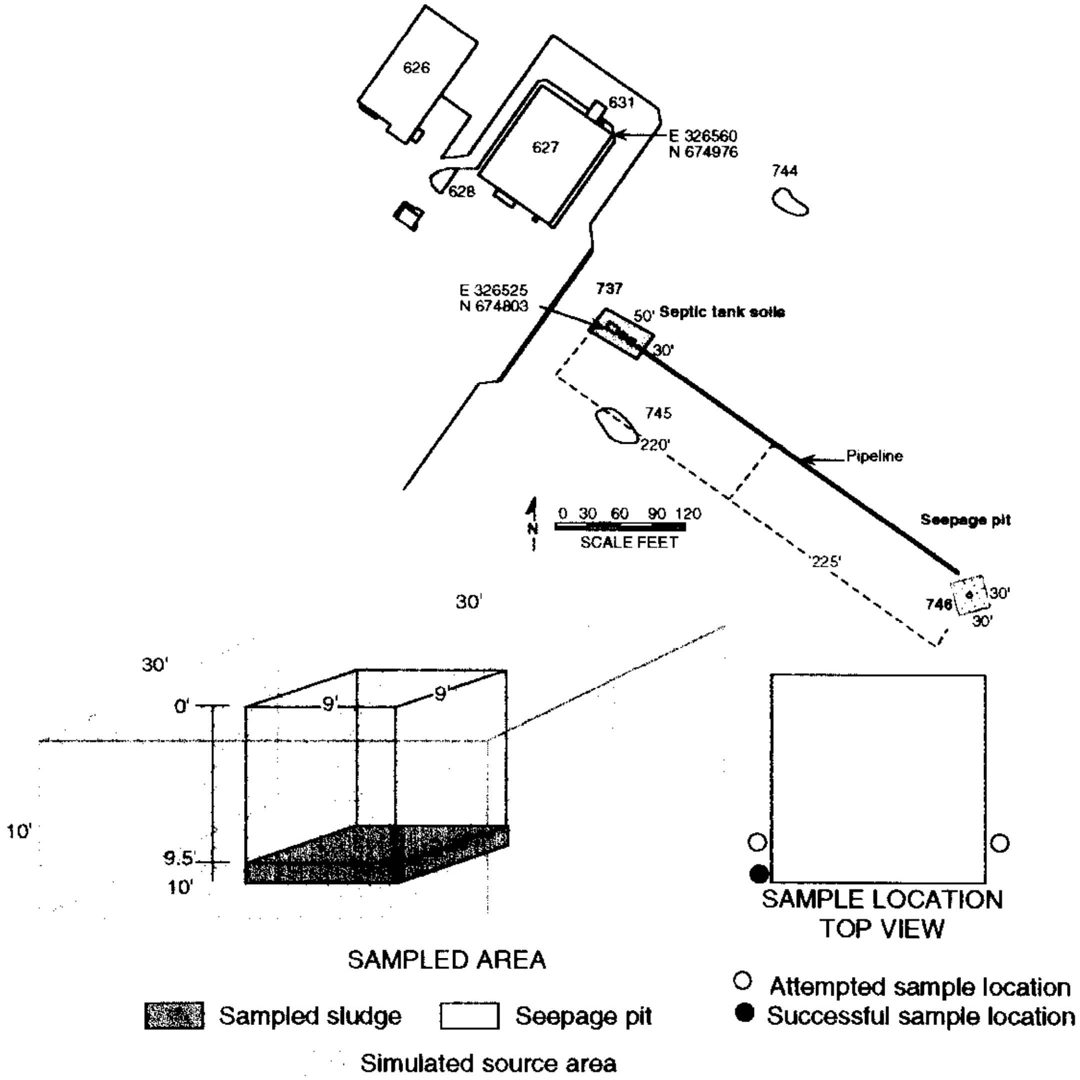
- Site ARA-25 (ARA-I contaminated soils beneath the ARA-626 hot cells) was forwarded to the FS to address the human health risks from Ra-226, Cs-137, and arsenic and to address the ecological risks from copper and lead.

- Site PBF-16 (SPERT-II leach pond) was forwarded to the FS to address the ecological risks from mercury in surface soil.



Ecological Contaminant of Concern	*Detected Range (mg/kg)*	*Exposure Point Concentration (mg/kg)*	*Ecological Hazard Quotient*
Selenium	1.5E-01 - 2.8E+01	2.8E+01	≤ 1 to ≤ 300
Thallium	1.0E+01 - 5.9E+01	3.7E+01	≤ 1 to ≤ 300

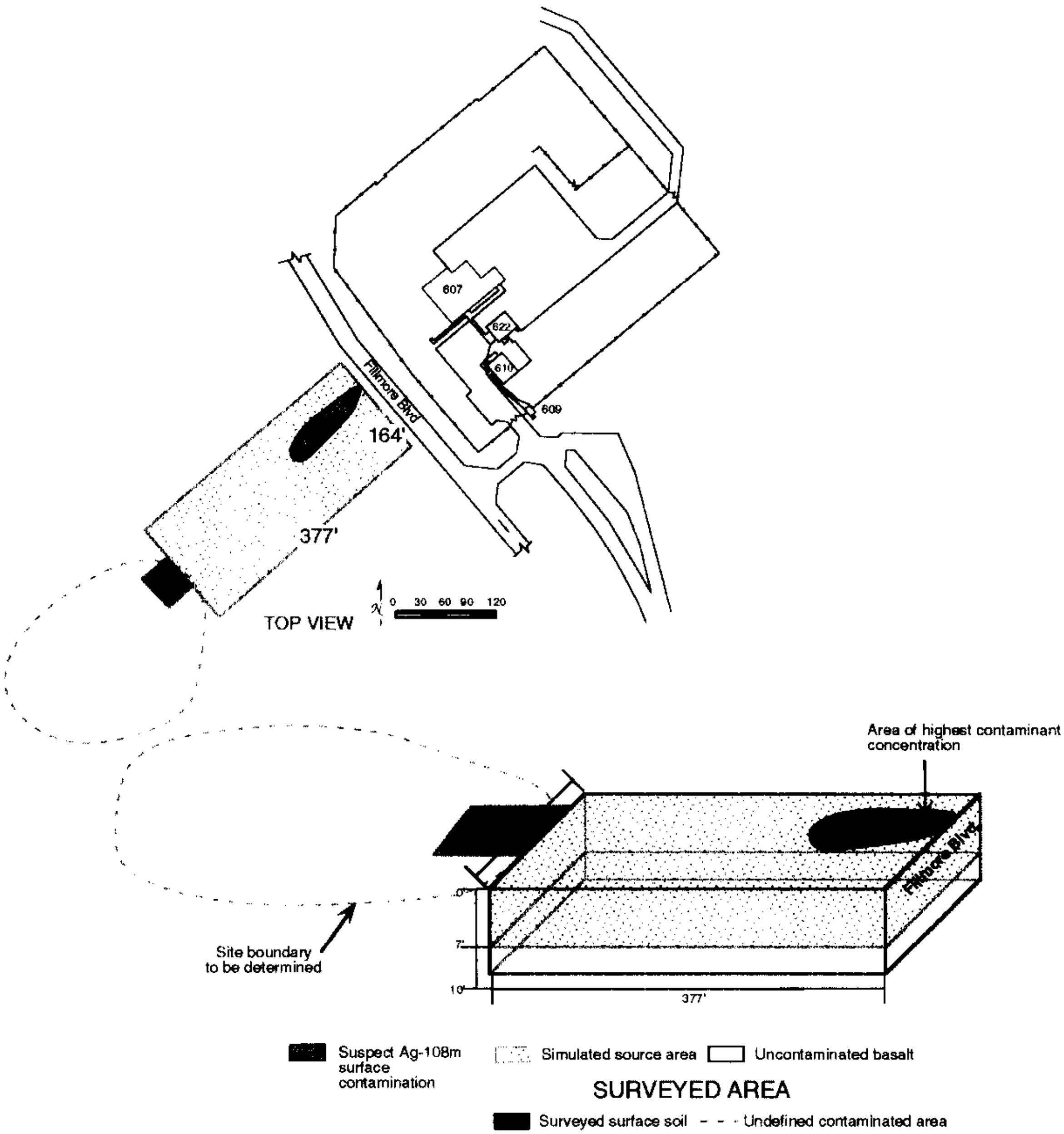
Figure 8-1. Site ARA-01, ARA-I Chemical Evaporation Pond, information for the feasibility study (ecological risk only).



Human Health Contaminant of Concern	*Detected Range (pCi/g)* minimum - maximum	*Source Term Concentration (pCi/g)* 0 to 0.5 ft	0 to 4 ft	0 to 10 ft	*Future Residential Human Health Risk*	*Primary Exposure Pathway*
Cs-137	6.16E+01 - 1.78E+02	0.00E+00	1.14E-01	1.50E+01	7E-05[a]	External radiation
Ra-226	3.29E+01 - 8.96E+01	0.00E+00	3.28E-01	9.60E+00	2E-03	External radiation
U-235	5.73E+00 - 1.20E+02	0.00E+00	2.92E-02	8.04E+00	9E-05[a]	External radiation
U-238	6.01E+00 - 1.90E+02	0.00E+00	3.44E-01	1.94E+01	3E-05[a]	External radiation
Human Health Contaminant of Concern	*Detected Range (mg/kg)* minimum - maximum	*Source Term Concentration (mg/kg)* 0 to 0.5 ft	0 to 4 ft	0 to 10 ft	*Future Residential Human Health Hazard Quotient*	*Primary Exposure Pathway*
Aroclor-1242	6.90E+00 - 2.35E+01	0.00E+00	0.00E+00	1.80E+00	2	Dermal absorption from soil

a. The combined risk from external exposure to radiation exceeds 1E-04 for Cs-137, U-235, and U-238.

Figure 8-2. Site ARA-02, ARA-I Sanitary Waste System Seepage Pit, information for the feasibility study (human health risk only).

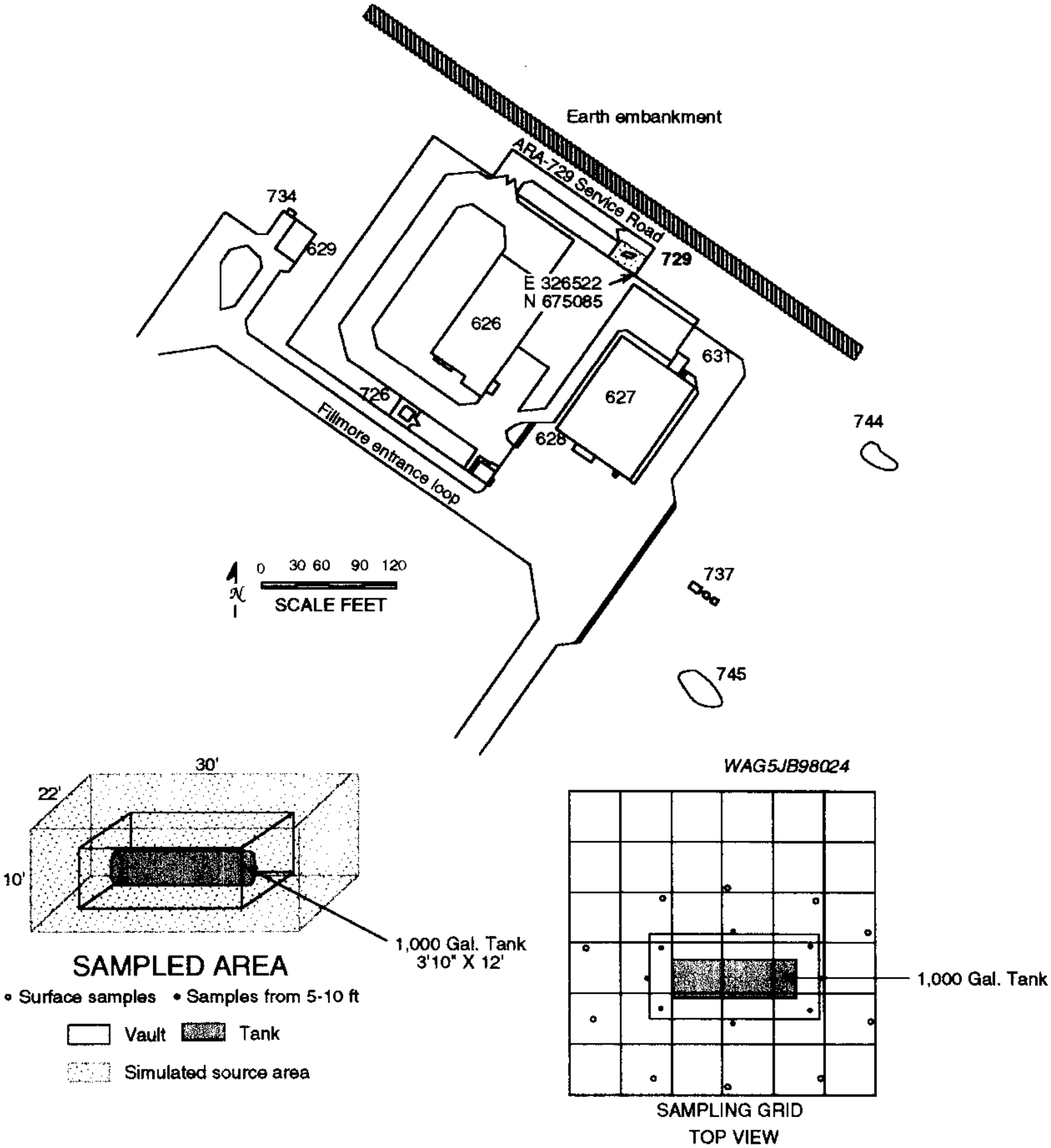


Human Health Contaminant of Concern	***Detected Range (pCi/g)*** minimum - maximum	***Source Term Concentration (pCi/g)*** 0 to .5 ft	0 to 4 ft	0 to 10 ft	***Future Residential Human Health Risk***	***Primary Exposure Pathway***
Ag-108m	2.33E-01 - 6.72E+01	6.72E+01	3.50E+01	2.08E+01	2E-03	External radiation
Cs-137	9.87E-02 - 4.42E+00	2.19E+00	1.33E+00	8.37E-01	2E-04[a]	External radiation

Ecological Contaminant of Concern	***Detected Range (mg/kg)*** minimum - maximum	***Exposure Point Concentration (mg/kg)***	***Ecological Hazard Quotient***
Copper	1.22E+01 - 6.23E+02	6.23E+02	≤ 1 to ≤ 300
Mercury	1.50E-01 - 1.40E+00	1.40E+00	≤ 1 to ≤ 90
Selenium	2.10E-01 - 2.70E+00	2.70E+00	≤ 1 to ≤ 30

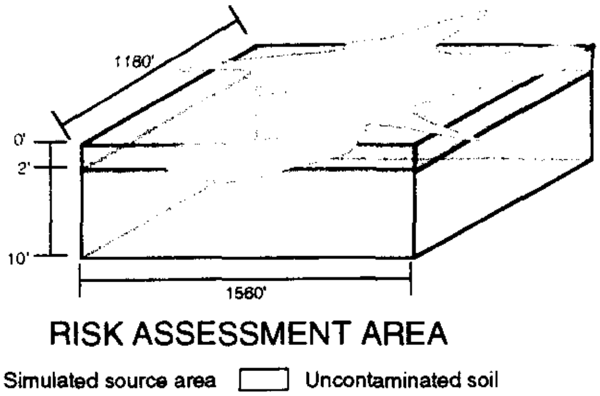
[a] Based on averaged GPRS data.

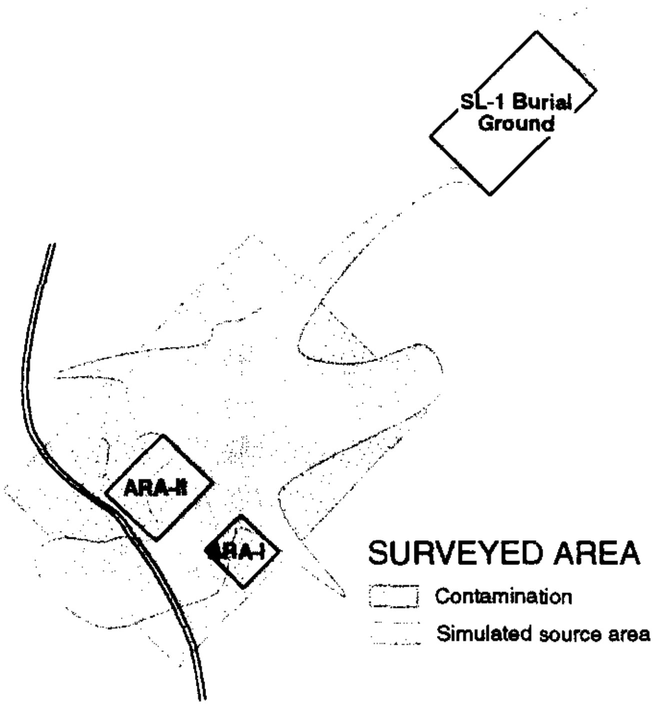
Figure 8-3. Site ARA-12, ARA-III Radioactive Waste Leach Pond, information for the feasibility study (human health and ecological risks).



Human Health Contaminant of Concern	*Detected Range (pCi/g)* minimum - maximum	*Source Term Concentration (pCi/g)* 0 to 0.5 ft	0 to 4 ft	0 to 10 ft	*Future Residential Human Health Risk*	*Primary Exposure Pathway*
Cs-137	2.70E-01 - 2.01E+02	1.26E+02	3.85E+01	3.18E+01	1E-04	External radiation

Figure 8-4. Site ARA-16, ARA-I radionuclide tank soil, information for the feasibility study (human health risk only).

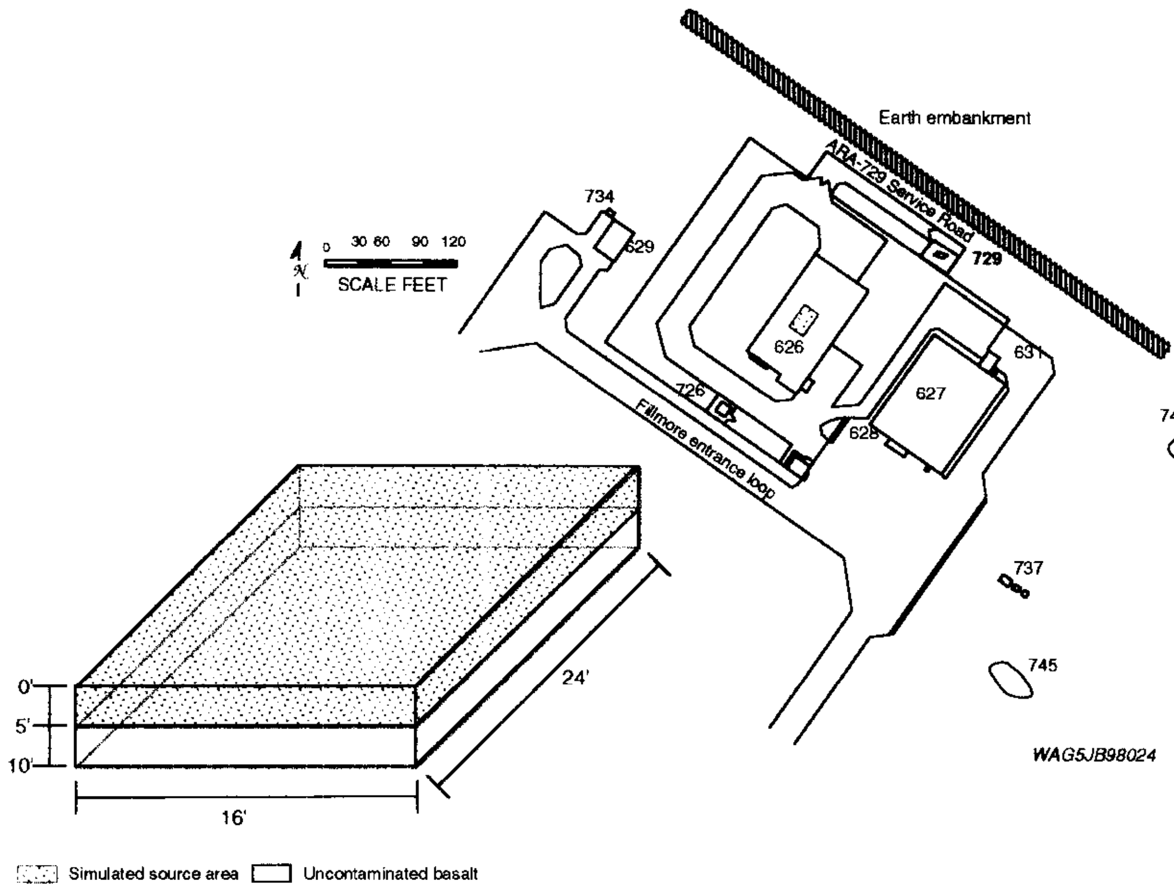




Human Health Contaminant of Concern	*Detected Range (pCi/g)* minimum - maximum	*Source Term Concentration (pCi/g)* 0 to 0.5 ft	0 to 4 ft	0 to 10 ft	*Future Residential Human Health Risk*	*Primary Expoerue Pathway*
Cs-137	8.00E-02 - 2.14E+03	2.92E+01	1.02E+01	4.09E+00	5E-04[a]	External radiation

[a] Based on averaged GPRS data

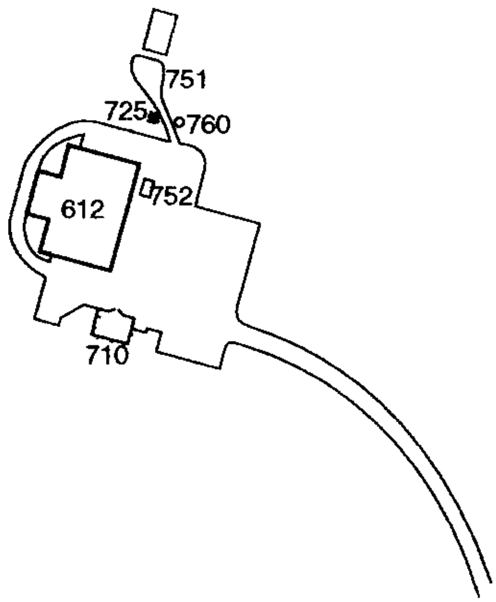
Figure 8-5. Site ARA-23, ARA-I and -II radiologically contaminated soils and subsurface structures, information for the feasibility study (human health risk only).

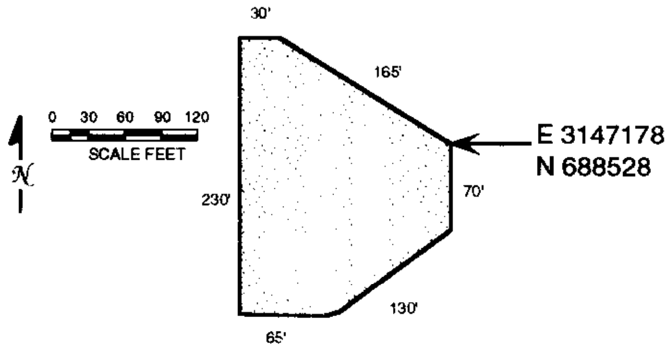


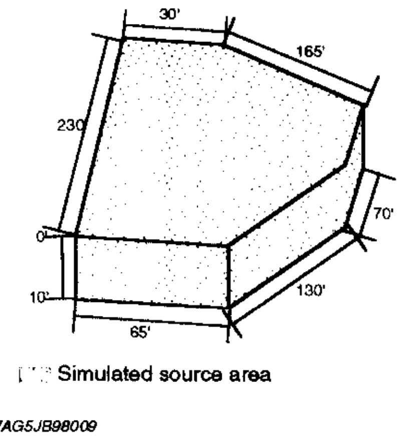
Human Health Contaminant of Concern	*Detected Range (mg/kg or pCi/g)* minimum - maximum	*Source Term Concentration (mg/kg or pCi/g)* 0 to 0.5 ft / 0 to 4 ft / 0 to 10 ft	*Future Residential Human Health Risk*	*Primary Exposure Pathway*
Arsenic	8.98E+00 - 4.06E+01	4.06E+01 4.06E+01 2.03E+01	3E-04	Dermal absorption from soil
Cs-137	2.26E+02 - 4.49E+02	4.49E+02 4.49E+02 2.25E+02	2E-03	External radiation
Ra-226	5.41E+00 - 2.97E+01	2.97E+01 2.97E+01 1.49E+01	5E-03	External radiation
Human Health Contaminant of Concern	*Detected Range (mg/kg)* minimum - maximum	*Source Term Concentration (mg/kg)* 0 to 0.5 ft / 0 to 4 ft / 0 to 10 ft	*Future Residential Human Health Hazard Quotient*	*Primary Exposure Pathway*
Arsenic	8.98E+00 - 4.06E+01	4.06E+01 4.06E+01 2.03E+01	2	Dermal absorption from soil
Arsenic	8.98E+00 - 4.06E+01	4.06E+01 4.06E+01 2.03E+01	1	Ingestion of soill

Ecological Contaminant of Concern	*Detected Range (mg/kg)* minimum - maximum	*Exposure Point Concentration (mg/kg)*	*Ecological Hazard Quotient*
Copper	1.15E+02 - 2.27E+02	2.27E+02	≤ 1 to ≤ 40
Lead	3.54E+00 - 1.43E+03	1.43E+03	≤ 1 to ≤ 900

Figure 8-6. Site ARA-25, ARA-I contaminated soil beneath the ARA-626 hot cells, information for the feasibility study (human health and ecological risks).







Contaminant of Concern	*Detected Range (mg/kg)* minimum - maximum	*Exposure Point Concentration mg/kg*	*Ecological Hazard Quotient*
Mercury	0.00E+00 - 7.10E-01	7.10E-01	≤ 1 to ≤ 50

Figure 8-7. Site PBF-16, SPERT-II Leach Pond, information for the feasibility study (ecological risk only).

Table 8-9. Individual sites and contaminants recommended for evaluation in the WAG 5 comprehensive feasibility study.

Site	Contaminant	Scenario	Risk	Hazard Quotient
		Residential		
ARA-02 (seepage pit sludge)	Aroclor-1242	Dermal absorption	NA	2
	Aroclor-1242	Ingestion of soil	NA	1
	Ra-226	External radiation exposure	2E-03	NA
	Cs-137	External radiation exposure	7E-05[a]	NA
	U-235	External radiation exposure	9E-05[a]	NA
	U-238	External radiation exposure	3E-05[a]	NA
ARA-12 (soil)	Ag-108m	External radiation exposure	2E-03	NA
	Cs-137	External radiation exposure	2E-04[b]	NA
ARA-16 (soil)	Cs-137	External radiation exposure	1E-04	NA
ARA-23 (soil)	Cs-137	External radiation exposure	5E-04[b]	NA
ARA-25 (soil)	Arsenic	Dermal absorption from soil	3E-04	2
	Arsenic	Ingestion of soil	9E-05[c]	1
	Cs-137	External radiation exposure	2E-03	NA
	Ra-226	External radiation exposure	5E-03	NA
	Ra-226	Ingestion of soil	1E-05[c]	NA
		Current Occupational[d]		
ARA-12 (soil)	Ag-108m	External radiation exposure	1E-03	NA
ARA-16 (soil)	Co-60	External radiation exposure	2E-04	NA
	Cs-137	External radiation exposure	3E-04	NA
ARA-25 (soil)	Arsenic	Dermal absorption from soil	1E-04	1
	Cs-137	External radiation exposure	4E-03	NA
	Ra-226	External radiation exposure	1E-03	NA
		Future Occupational[d]		
ARA-12 (soil)	Ag-108m	External radiation exposure	2E-03	NA
ARA-25 (soil)	Arsenic	Dermal absorption from soil	1E-04	1
	Cs-137	External radiation exposure	4E-04	NA
	Ra-226	External radiation exposure	1E-03	NA

Table 8-9. (continued).

Site	Contaminant	Scenario	Risk	Hazard Quotient
		Ecological		
ARA-01 (soil)	Selenium	Ecological exposure	NA	≤ 1 to ≤ 300
	Thallium	Ecological exposure	NA	≤ 1 to ≤ 300
ARA-12 (soil)	Copper	Ecological exposure	NA	≤ 1 to ≤ 300
	Mercury	Ecological exposure	NA	≤ 1 to ≤ 90
	Selenium	Ecological exposure	NA	≤ 1 to ≤ 30
ARA-25 (soil)	Copper	Ecological exposure	NA	≤ 1 to ≤ 40
	Lead	Ecological exposure	NA	≤ 1 to ≤ 900
PBF-16 (soil)	Mercury	Ecological exposure	NA	≤ 1 to ≤ 50

a. The cumulative risk for Cs-137, U-235, and U-238 in the seepage pit is greater than 1E-04. Therefore, these three COCs were retained for the feasibility study.

b. ARA-12 and ARA-23 were surveyed using the global positioning radiometric scanner (GPRS) and the detected counts per minute were converted to Cs-137 concentrations. If concentrations are assumed to be limited to the top 1-in. of soil, the associated external exposure risk in the 100-year future residential scenario is 5E-04 for ARA-23. The risk estimate is likely underestimated because of the averaging technique used to convert the GPRS data to Cs-137 concentrations. Adding risk for other pathways (e.g., inhalation of fugitive dust and ingestion of soil) would increase the cumulative risk estimate even further. The risk estimate for ARA-12 would increase similarly. However, the GPRS survey at ARA-12 detected a previously undefined area of contaminated soil adjacent to ARA-12 and the site boundary will be expanded. As indicated in Section 3.1.12, the extent of contamination will be defined and the site reevaluated.

c. Cumulative risk for the ingestion of soil pathway for ARA-25 equals 1E-04.

d. Estimated risks from the occupational scenarios were not used to retain sites or identify contaminants of concern for evaluation of remedial alternatives in the feasibility study.

8.7 References

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